

OBSERVATIONS

ON THE

NERVOUS SYSTEM.



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ON THE

STRUCTURE AND FUNCTIONS

OF THE

NERVOUS SYSTEM.

ILLUSTRATED WITH

T A B L E S.

BY

ALEXANDER MONRO, M.D.

PRESIDENT OF THE ROYAL COLLEGE OF PHYSICIANS,
AND PROFESSOR OF PHYSIC, ANATOMY, AND SURGERY
IN THE UNIVERSITY OF EDINBURGH.

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C. B. S. R. V. A. T. I. O. N.

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NEW YORK



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OBSERVATIONS

STUDIES

NEW YORK



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THE RIGHT HONOURABLE

H E N R Y D U N D A S, Esq;

LORD ADVOCATE FOR SCOTLAND,

&c. &c. &c.

NOT MORE EMINENTLY DISTINGUISHED

BY HIS ABILITIES,

THAN BY HIS CANDOUR AND BENEVOLENCE,

THIS WORK IS,

WITH MUCH RESPECT,

DEDICATED

BY THE AUTHOR.

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HENRY O. U. S. A.

LORD ADVOCATE

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THE CONTENTS.

	Pag.
INTRODUCTION	I
CHAP.	
I. <i>Of the circulation of the blood within the head</i>	2
II. <i>Of the membranes of the brain and cerebellum in general</i>	8
III. <i>Of the communication of the ventricles of the encephalon with each other, as described by former authors</i>	9
IV. <i>Of the communication of the ventricles of the encephalon with each other, by the Author</i>	12
V. <i>Of the absorbent vessels of the encephalon, and of the infundibulum and glandula pituitaria</i>	17
VI. <i>Of the use of the ventricles of the encephalon</i>	21
VII. <i>Of the cineritious and medullary substances of the brain and cerebellum</i>	22
VIII. <i>Of the supposed origin or formation of nerves</i>	24
IX. <i>Of the structure of the spinal marrow</i>	28
X. <i>Of the pia mater, the colour and texture of the nerves</i>	32
XI. <i>Conclusions drawn from the three last sections</i>	35
XII. <i>Order of the subsequent chapters mentioned</i>	37
XIII. <i>Of the appearance of the nerves in their course, and particularly of their folds or joints</i>	38
XIV. <i>Of the connection of the nerves in their course</i>	41
XV. <i>Of the plexuses of nerves</i>	42
XVI. <i>Of the connection of the nerves which run in opposite directions, so as to be joined by their small branches</i>	43
b	XVIII.

CHAP.	Pag.
XVII. <i>Of the connection of the several cords which compose each of the nerves</i>	44
XVIII. <i>Of the external covering of the trunks of the nerves, and of the cords or funiculi of which they consist</i>	48
XIX. <i>Of the ganglia of the nerves</i>	50
XX. <i>Of spheroidal bodies which, in some animals, make part of the ner- vous system</i>	59
XXI. <i>Of some principal nerves which have not been properly traced by authors</i>	62
XXII. <i>Of the appearance of the nerves viewed with the microscope</i>	67
XXIII. <i>Of the nature of the energy of the nerves</i>	74
XXIV. <i>Of the uses of the nerves</i>	77
XXV. <i>Whether the nerves convey the nourishment to our organs</i>	78
XXVI. <i>Of sensation</i>	88
XXVII. <i>Of the termination of the nerves in the muscular organs ; and whe- ther muscles possess a vis insita different from the vis nervea</i>	90
XXVIII. <i>Of the manner and causes of the actions of the muscles</i>	95

EXPLANATION of the TABLES.

TABLE	Pag.
I. <i>THIS table shews, in a foetus calf, the structure of a plexus formed by the internal carotid artery, called by Galen Rete Mirabile</i>	105
II. <i>In this table the human cranium, the brain, and the nose, are represented cut perpen- dicularly, close to the right side of the falx cerebri and septum narium</i>	106
III. <i>The figures in this table represent the communication of the lateral ventricles of the human brain with each other, and with the third ventricle</i>	108
IV. <i>In this table farther views are represented of the communication of the lateral ven- tricles of the human brain with each other, and with the third ventricle. The anterior parts are here turned towards the bottom of the table</i>	110
V. <i>In this table a view is given of the human crura cerebri and cerebelli, of the tuber annulare, and medulla oblongata, after dissecting away from them the arachnoid coat and pia mater, in order to shew the general direction of their medullary fibres</i>	112

VI. *This*

C O N T E N T S

vii

TABLE

Pag.

VI. This table represents a perpendicular section in the human subject, of the corpus striatum, thalamus nervi optici, crus cerebri, tuber annulare, pineal gland, commissura cerebri posterior, nates, testis, cerebellum, and fourth ventricle, with a view of the medulla oblongata	114
VII. In figure I. is represented a section of the human brain and cerebellum, with their crura, the tuber annulare and medulla oblongata, in order to shew a great intermixture of cineritious substance with the medullary, and very various directions and interlacing of the bundles of the medullary fibres	115
VIII. This table represents the heads of children born at the full time, in which the bones, which generally form the top of the cranium, are wanting, and in which the brain, which is extremely small, projects like an excrescence.	116
VIII. * In this table the brain found in an imperfect state, in two children, and the nerves of the head, neck, and arm, are represented	117
VIII. ** In this table are represented the parts of a human female monster, in which there are two heads, and the bones, muscles, and nerves of two trunks, two pairs of lungs, and two stomachs; but only two arms and two legs, two renal glands, and two kidneys, one liver and spleen, and one heart, consisting of one auricle, and one ventricle only	119
IX. This table represents the structure of some principal parts of the brain and of the spinal marrow in a sheep	121
X. This table represents a fore view of the spinal marrow of a man, after cutting away the bodies of the vertebrae, laying open the sheaths formed by the dura mater and arachnoid coat, and cutting the anterior bundles of the spinal nerves	124
XI. In this table are represented, in a man, (after cutting off the bodies of the dorsal vertebrae) the structure of the surface of the spinal marrow, the rise of the anterior and posterior bundles of the dorsal nerves, a ganglion in the posterior bundle, and the connection of the two bundles with each other, and with the great sympathetic nerve	126
XII. In the four Figures of this table the parts of a monstrous kitten are delineated of their natural size. It appears to have one head and two bodies, each with four legs 1, 2, 3, 4, 5, 6, 7, 8.	128
XIII. All the figures of this table (except the last, viz. Fig. 15.) represent the appearance of the nerves of man, quadrupeds, birds, amphibia, fishes, when carefully viewed with the naked eye, or with a magnifying glass	130
XIV. The two figures of this table shew the appearance of the sciatic nerves twelve months after they had been cut across and rejoined in living frogs	132
XV. Repre-	

TABLE	Pag.
XV. Represents the human axillary plexus of nerves on the right side -	133
XVI. This table represents the five undermost cervical subvertebral nerves, with the first dorsal nerve of the human subject, taking their rise from the spinal marrow, and joining to form the brachial plexus, which is fully dissected to shew the connections of its nerves - - -	135
XVII. This table represents the axillary plexus of nerves dissected in another subject, and its parts distinguished by the same figures as in the preceding table	137
XVIII. This table represents the threads which compose the radial nerve of Monro, or median nerve of Winslow, traced by dissection - - -	138
XIX. This table is intended to shew the way in which the branches of the different nerves of the face are connected - - -	139
XX. This table represents a ganglion in the trunk of the fifth pair of the nerves of the head in man - - -	140
XXI. Represents different parts of the human great intercostal or sympathetic nerve	141
XXII. In this table the structure of the first cervical ganglion of the great sympathetic nerve is delineated in the sheep and ox - - -	143
XXIII. This table represents the structure of the thoracic ganglia of the great sympathetic nerve of an ox, and the manner in which these are connected with the proper dorsal or intercostal nerves - - -	144
XXIV. The three first figures of this table represent the distribution, in the human subject, of the branches of the first, or olfactory pair of nerves, and of the nasal branch of the fifth pair upon the membrane of the nose. The three last figures represent the same nerves in a sheep - - -	146
XXV. In this table some of the branches of the nerves of the teeth and gums of a child, after birth, are delineated, after cutting off the outer part and base of the lower jaw-bone - - -	149
XXVI. This table represents a small but constant branch of the muscular spiral nerve of the human arm, which is connected to, and appears to terminate chiefly in, the back part of the capsular ligament of the wrist - - -	150
XXVI. * This table is chiefly intended to shew a plexus formed by the joining of the recurrent nerves with the superior laryngeal, and the termination of their branches in the muscles and ligaments of the larynx. The nerves of the tongue are likewise delineated - - -	151
XXVII. This table represents, in a child, a nerve which is contained in the canalis pterygoideus of the sphenoid bone, and which joins the second branch of the fifth pair	

C O N T E N T S.

ix

TABLE	Pag.
pair of nerves to the first ganglion of the great sympathetic nerve, and to the portio dura of the seventh pair - - -	153
XXVIII. This table represents the human chorda tympani joining the portio dura of the seventh pair to the lingual branch of the third branch of the fifth pair - - -	154
XXIX. In this table the semicircular canals and cochlea of the human left ear are represented, with the holes in the bones for the passage of the seventh pair of nerves - - -	155
XXX. Represents the os petrosum dissected, after being softened, so as to shew the distribution of the portio dura and portio mollis of the seventh pair, but chiefly of the latter - - -	158
XXXI. In this table, the membrane lining the human cochlea, with the nerves from the portio mollis of the seventh pair, are represented with the utmost accuracy - - -	160
XXXII. Figure first represents the upper part of the brain and spinal marrow of a haddock, and figures second and third the top of the spinal marrow of a cod, with the nerves issuing from these, and certain spheroidal bodies loosely connected to the brain, but closely to the nerves - - -	162
XXXIII. This table represents the nerves of the fin of a haddock, with spheroidal bodies connected to them, magnified to six diameters - - -	164
XXXIV. Figure first of this table represents the spinal marrow and nerves in the tail of a small haddock, dissected, and magnified to four diameters - - -	165
XXXV. This table shews the appearance of the branches of the portio mollis dispersed on the human cochlea, viewed in the sun-shine with a double microscope, which enlarges the diameter 146 times - - -	166
XXXVI. Figures first, second, and third, shew the appearance of the retina of the human eye, when viewed in the sun-shine with the microscope - - -	167
XXXVII. Represents portions of the dura and pia mater, of the brain, the nerves and their ganglia, viewed with a double microscope, which enlarges the diameter 146 times - - -	168
XXXVIII. The three figures in this table represent the appearance of the muscular fibres, and nerves entering them, when viewed, in sun-shine, with a double microscope which increases their diameter 146 times - - -	169
XXXIX. Represents portions of the blood-vessels, the pleura, the lungs, the bones, the nails, viewed with a double microscope, which increases the diameter 146 times - - -	ib
XL. In this table, the appearance of a perpendicular section of the papillae of the skin of the finger after the cuticula was detached by putrefaction, is represented magnified to 146 diameters. - - -	170

TABLE

Pag.

- XLI. *This table represents the appearance of the parts which compose the common teguments, illuminated by sun-shine, and viewed through a microscope which increases the diameter 146 times* - - 171
 XLII. *This table shews the appearance of a mite, viewed in the sun-shine with a double microscope, which magnifies the diameter 146 times* - 172
 XLIII. *This table represents the appearance of some of the parts of vegetables viewed with the microscope* - - - - ib
 XLIV. *The several figures in this table represent an appearance of serpentine fibres in the metals, semimetals, stone, gum, solid oily bodies, salt, when viewed in sun-shine with a microscope which magnifies the diameter 146 times* 173
 XLV. *In this table the appearance is represented of different metals, viewed with a microscope which enlarges the diameter 146 times* - 174
 XLVI. *This table represents the appearance of very numerous vessels, injected in cicatrices, which supplied the place of portions of the skin of a pig which had been cut out* - - - - 175
 XLVII. *Figures first and second of this table represent vessels injected from the aorta, in a portion of the skin of the abdomen of a pig, which, before the injection was made, had been completely detached from the neighbouring parts, by incisions made at different times* - - - 176

OBSERVATIONS

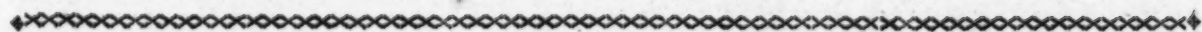
OBSERVATIONS

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INTRODUCTION.

AS the Nervous System is the medium interposed between the living principle and the several organs which compose the bodies of animals, an exact knowledge of its structure and functions must appear to the philosopher, as well as to the physician, of high importance in the study of nature.

The brain, cerebellum, medulla oblongata, medulla spinalis, and the nerves, with their ganglia, form this system.

Of these parts I shall treat in the order in which I have enumerated them, confining my observations, as much as possible, to such facts and circumstances as have not been ascertained, or have been altogether overlooked by anatomists and physiologists.

A

CHAP.

CHAPTER I.

Of the Circulation of the Blood within the Head.

SECTION I.

IT has been justly observed by authors, that the force of the blood sent to the brain and cerebellum in man is broken by its ascent; by the angles at the rise of the internal carotid and vertebral arteries; by the turns which these form in their course, for instance, by the turns of the internal carotids within the os petrosum and at the sides of the fella turcica; and by the uncommonly great proportion which the sum of the areas of the branches bears to the area of the trunk.

But this intention of nature appears more evidently in the ruminating quadrupeds; for I find that a substance connected with the internal carotid artery, observed by Galen and named by him *rete mirabile*, which by Heister and others has been called *plexus vasorum et fibrarum*, *usus incogniti**, consists entirely of a division of that artery into small serpentine branches, which are afterwards collected, at the side of the fella turcica, into a trunk that is divided nearly as in man†; and the vertebral arteries, I likewise observe, form a *rete mirabile*.

But, although the momentum of the blood is thus broken, the quantity of it which circulates in the brain is greater than in most organs of the same weight. Thus one of our arms will be found to weigh more than our brain and cerebellum; yet the areas of the two vertebral and of the two internal carotid arteries, joined together, are much larger than the area of the proper subclavian artery.

This

* See Heister *Comp. Anat.* p. 138. § 273.

† See T. I.

This quantity of blood does not, however, so greatly exceed the proportion of that circulated in most other parts, as Dr Keil, Dr Boerhaave, and Dr Haller, have endeavoured to prove; for those very learned authors, instead of comparing the areae of the internal carotid and vertebral arteries with the area of the trunk of the descending aorta *, ought to have compared them with similar branches sent off from that trunk. On a just comparison, not above one tenth part of the whole mass is circulated within the head; which is, however, nearly four times more than, in general, is circulated in the rest of the aortic system, as the weight of the encephalon does not exceed one fortieth part of the weight of the whole body.

S E C T. II.

IN the brain, the small circulating veins are known to terminate in sinuses, or in trunks covered by the dura mater; and their passage through the dura mater, or between it and the proper trunk of the veins, is oblique; nay, the mouths of many of those veins are turned in a direction contrary to the current of the blood in the sinus †. But it is further to be observed, that, while one side of the sinus is firmly fixed to the bone excavated for its reception, the other side of it either has the dura mater drawn tense over it, as in the sinuses at the basis of the cranium; or is drawn out into an angle by the falx cerebri, or tentorium cerebello superextensum, as is the case of the superior longitudinal and part of the lateral sinuses; or, as in the torcular Herophili, the tentorium forms the basis of the triangular sinus, whilst the opposite angle is supported by the falx. In the last place, the terminations of the great veins or sinuses, or ends of the lateral sinuses, are not contiguous to the trunks of the corresponding arteries, as is observed in most other parts of the body, but pass through different holes of the cranium.

S E C T.

* Boerhaave Prael. in Inst. § 239. and Haller, El. Phys. V. 4. p. 140.

† Haller, El. Phys. T. 4. p. 148.

S E C T. III.

SOME eminent physiologists have regarded the sinuses as considerable receptacles of blood, and have proposed theories to explain the cause or effects of the accumulation of blood in them. But, when we consider that the vertebral arteries are accompanied by small veins only, and, of course, that almost the whole blood which these as well as the internal carotid arteries convey, is returned by the lateral sinuses and their continuation, the internal jugular veins, it will appear, that the venous trunks within the head are not much, if at all, larger than veins are, with respect to corresponding arteries, in other bowels, as in the kidneys, spleen, &c.

S E C T. IV.

THE primary uses of the structure described are, therefore, 1. That when, by a sudden and violent action of the muscles of expiration, or of the muscles of the head and neck, the blood is repelled in the cavæ or internal jugular veins, the impulse may not be communicated to the blood in the small and tender veins of the brain, which would endanger a rupture of these. To confirm which, it may be observed, that, generally, a very small quantity only of any liquor injected into the sinuses enters the small veins of the brain and cerebellum.

2. The dura mater, investing the trunks of the veins of the brain and cerebellum, evidently strengthens these, and prevents their being easily ruptured.

3. The dura mater stretched over the sinuses, which are lodged in furrows of bones, and its processes, the falx and tentorium, connected to angles of the sinuses, prevent the opposite sides of the sinuses from being pressed nearer to each other, or prevent their cavities from being much diminished by the weight of the parts of the brain and cerebellum in different

rent postures; or by an increased impulse of the blood in the arteries; or by water accumulated in the ventricles of the brain, or on its surface; or by scirrhus or other tumours forming in its substance.

To illustrate this effect of the falx and tentorium upon the sinuses: If, after taking out the brain and cerebellum, we cut the falx and tentorium, and dry the head, the cavities of the superior longitudinal sinus, of the two lateral sinuses, and of the torcular Herophili, will be found much diminished: But, if the falx and tentorium are preserved entire, though we dry the head, the cavities of the sinuses will be so little diminished, that we would suppose they had been purposely kept inflated, whilst the head was drying.

4. The ends of the lateral sinuses perforate the cranium at some distance from the arteries, that the returning blood might, as little as possible, suffer interruption in its course towards the heart.

For any alternate stop of it, especially when occasioned by the stroke of the corresponding artery, must have had a worse effect on the brain than on other organs; not merely on account of the delicacy of the brain, and the thinness of its veins, but because, being inclosed in a case of bone, the blood must be continually flowing out by the veins, that room may be given to the blood which is entering by the arteries. For, as the substance of the brain, like that of the other solids of our body, is nearly incompressible, the quantity of blood within the head must be the same, or very nearly the same, at all times, whether in health or disease, in life or after death, those cases only excepted, in which water or other matter is effused or secreted from the blood-vessels; for in these, a quantity of blood, equal in bulk to the effused matter, will be pressed out of the cranium.

S E C T. V.

It does not, however, follow from this, that every individual artery or vein within the head is constantly of the same size, or that, at all times, it

B

contains

contains the same quantity of blood, and, of course, that the arteries within the head are immoveable, like metalline tubes, or want pulsation, or are unfusceptible of inflammation. For, whilst the heart is performing its systole, the arteries here, as elsewhere, may be dilating, and, in the mean time, a quantity of blood, equal to that which is dilating them, is passing out of the head by the veins.

During the succeeding period of diastole of the heart and systole of the arteries, the quantity which dilated the arteries of the brain passes into the corresponding veins and sinuses; at the same time, as much passes from the sinuses out of the head, as enters into the head from the contracting trunks of the arteries situated between the heart and the head.

S E C T. VI.

NEITHER does it follow, from nearly the same quantity of blood being at all times contained within the head, that opening the arteries or veins on the outside of the head, or in the limbs, can be of no service in the cure of inflammation, apoplexy, and other diseases of the brain. For, although we cannot, by arteriotomy or venesection, lessen much the quantity of the blood within the cranium, we can diminish the force with which it is impelled into it. The great effect of this circumstance needs no other proof than that, in cases of faintness, brought on by inanition, we are relieved by the horizontal posture, and, in cases of plethora, or of inflammation of the brain, we are oppressed by that posture. Nay, the less compressible we suppose the substance of the brain to be, the more readily we understand how the whole of it may be affected by a plethora, or increased momentum of the blood; or a particular part of it injured by an inflammation, or by an extravasation of the blood, or by any other cause of pressure upon its substance.

S E C T. VII.

IN phrenitis, apoplexy, and other diseases, it has been proposed to perform the operation of the trepan, in order that the external air admitted might, by its pressure, lessen the diameter of the vessels.

But,

N E R V O U S S Y S T E M.

But, allowing we were to lay out of the question the dangerous effects which the air has upon all our deep seated organs, I would observe, that, if the diameter of the vessels should be diminished by the admission of the air, this effect can only be explained on the principle, that the vessels are exposed to more pressure after, than they were before trepanning, from which surely no good effects can be expected. We might, almost, as well propose, in peripneumony, to perform the paracentesis of the thorax.

S E C T. VIII.

BEFORE dismissing this subject, it may be worth while to mention, that, in 1752, I made an experiment, with the assistance of Dr Brodie, which plainly shewed, that, in animals killed by hanging, death was not, as Petit supposed, owing chiefly to the pressure on the vessels of the brain, but depended on the stoppage of respiration.

I cut a large hole in the trachea of a living dog. I then suspended him for three quarters of an hour, by a rope fixed around his neck above that hole, without killing him or depriving him either of sense or motion. But, when we afterwards suspended him, for a quarter of an hour, by a rope fixed under that hole, he became insensible, and did not recover.

Dr Stolte, an ingenious Dutch physician, has confirmed this fact, by a variety of similar experiments, of which he has given an account in his Inaugural Dissertation in 1764.

C H A P.

CHAPTER II.

Of the Membranes of the Brain and Cerebellum in general.

AFTER removing the cranium and the dura mater, the latter of which, beside the offices already mentioned, serves as periosteum to the inner layer of the cranium, and as a cushion to defend the brain from the bone, we find the brain and cerebellum covered by two membranes called the arachnoid coat and pia mater.

The arachnoid coat has no vessels which convey red blood, and is extremely thin and tender. At the bottom of the brain it is easily demonstrated; but at the top of the brain it is much less evident.

The pia mater covers not only the external surface of the brain and cerebellum, and enters by processes or doublings into all their furrows, but also lines certain cavities called the Ventricles.

I would observe, however, that there are not only fewer large vessels dispersed within the ventricles than upon the surface of the brain, but that there are fewer small vessels, as we cannot, by an injection, make the pia mater, lining them, so red as that on the surface of the brain.

C H A P T E R III.

Of the Communication of the Ventricles of the Encephalon
with each other, as described by other Authors.

THERE are four ventricles within the human encephalon, to wit, two called lateral ventricles within the hemispheres, into which the brain is divided : A third ventricle lies under a septum, between the lateral ventricles : A fourth is situated between the tuber annulare and cerebellum.

These cavities have been described by Galen, and by many succeeding Authors of eminence, as all communicating with each other* ; and the fourth ventricle has by some eminent authors, particularly by Dr Haller, been supposed to communicate with the cavity of the spinal marrow †.

The manner of the communication of the third ventricle with the fourth has been generally well understood.

A hole or passage at the upper and fore part of the third ventricle has not only been described, but painted by different authors, under the name of Vulva ‡. A few authors likewise have mentioned a place under the for-

C

nix,

* Galen de Ufu partium, Lib. 8. cap. 2.—Vesalius de C. H. Fabrica, Lib. 4. cap. 2.—Spigelius de H. C. Fabrica, Lib. 10. cap. 8.—Arantius, Tab. Anatom. Lib. 10.—Bauhinus, Th. Anat. Lib. 3. cap. 13.—Vieussens, Neur. Univ. Lib. 1. cap. 1.—Willis, Cerebri Anatome, Cap. 2. p. 10. Ridley, Anat. of the Brain, Cap. 13.—Cowper, Ap. to B.—Verheyen An. Lib. 4. cap. 6.—Winslow, An. Tr. de la Teste, 70. 81. 84.—Heister, C. Anat. 270. p. 135.

† Haller, El. Phys. Lib. 10. S. 2. § 6. p. 77. et S. 3. § 7. p. 87.

‡ Vesalius An. L. 7. T. 6. et 7.—Arantius, Lib. 10. T. 4. 5. 6.—Vieussens Neur. Tab. 7. 8.

nix, to which they have given the name of Anus, where they supposed the lateral ventricles to communicate with each other, and with the third ventricle*.

But it may be observed,

1. That no author has *delineated* the beginning of the passages by which the lateral ventricles can discharge their contents into the third ventricle.
2. If a few have described the place where we shall in reality find such a communication, there is some reason to suppose that they had been led to the mention of that place, by taking it for granted that the anterior hole of the third ventricle served such a purpose, rather than from their having actually seen the passage, as they have not painted, and do not describe its appearance before the fornix is raised †.

2. Those who described an anterior hole under the name of Vulva, have described also a posterior, under the name of Anus; which they supposed to communicate with the anterior ventricles ‡. Yet it will appear, that this place (which is bounded behind by the pineal gland and its connection to the commissura cerebri posterior, at the sides, by the peduncles, or medullary processes, from the pineal gland to the thalami nervorum opticorum, and before, by the conjoined thalami nervorum opticorum) is completely shut by a vascular membrane between it and the fornix.

3. The most eminent of the late authors who knew the descriptions of former authors, and had particularly examined the subject, have doubted of, or denied such communications of the lateral ventricles with each other,
or

* Vieussens, Neur. Lib. 1. p. 64.—Winflow, Anat. Tab. de la Teste, 70. 81. 84.—Lieutaud, Anat. H. 5. S. p. 338.

† Vieussens, l. c. Lieutaud, An. H. Pl. Set 2. et An. Pr. p. 620.

‡ Vieussens, Lib. 1. p. 64. Anus vero alterum est foramen subtus posticam fornicis partem latitans, et juxta nates excavatum, quo intermedio anteriores ventriculi cum tertio pariter communicant.

or with the other ventricles *, or have so entirely overlooked or missed such communications, that, in the figures they have given, they have not ventured to paint any of the places at which it had been said they were to be found †; and, as a proof that there is no natural communication, they have remarked, that, in the hydrocephalus internus, the water had filled only one of the lateral ventricles ‡.

C H A P.

* Steno, Cer. Anat. p. 34. 'Ut valde suspectum habeam utrum ea via (fissura quae sub fornice latet) communicant inter se anteriores ventriculi et posteriores,' &c.—Senac, Sup. a l'Hist. du Coeur, Ch. 10. p. 689. Je vous ai prié d'examiner s'il y a un véritable communication entre les ventricules du Cerveau: J'ai cru appercevoir une membrane qui couvre des ouvertures qu'on croit libres.—Haller, El. Phys. L. 10. § 18. p. 42. 'Leniter tamen impulsio flatu non reperi aërem a dextra cavea in finistram transiisse, aut aquam, in alterius lateris ventriculum missam, agitasse; § 29. p. 57. Sed neque antè, inter fornicis crura anteriora, septum lucidum et hunc plexum, ostium ullum me meminisse invenisse; neque clari ante me viri viderunt.'—§ 27. p. 55. 'Cum ventriculis anterioribus, quando omnia integra sunt, non communicat (scilicet ventriculus tertius) cum illi aqua pleni, ipse inanis repletus sit, et cum plexu, quem diximus, imposito finiatur.'—§ 29. p. 57. Verum haec imperfecta in cilia (scilicet veterum meatus et Willisii vulvam et anum) non a lateralibus ventriculis ad tertium, sed a tertii superiori cavea ducunt ad inferiorem.

† P. Tarin *Adversaria Anatomica prima*, de omnibus Cerebri, &c. Descriptionibus et Iconis, 1750. Tab. 2. Fig. 1. And the otherwise very accurate and ingenious S. T. Soemmerring de *Basi Encephali*, &c. cum tabulis *Aeneis*, 1778, Tab. 3. have delineated the brain cut perpendicularly at its middle, without pointing out, or seeming to know, the communication of the lateral ventricles with each other, or with the third ventricle.

In like manner, J. J. Plenck, in his *Primae Lineae Anatomiae*, 1775, and F. Leber, in his *Praelectiones Anatomicae*, editio nova, 1778, make no mention of any such communications.

‡ Haller, El. Phys. L. 10. § 18. p. 42.

CHAPTER IV.

Of the Communication of the Ventricles of the Encephalon
with each other, by the Author.

S E C T. I.

AFTER laying open one of the lateral ventricles of the brain in the usual way, leaving the septum between the ventricles entire, let the gutter which is between the corpora striata and thalami nervorum optico-rum, the bottom of which is occupied by the substance called Centrum semicirculare geminum, be traced inwards, and it will be found to lead to the fore part of an oval hole, large enough to admit a goose quill, under the fore part of the fornix. From this hole, a probe can be readily passed into the other lateral ventricle, shewing, in the first place, that the* two lateral ventricles communicate with each other. When the fornix is next divided transversely, we find that this passage has the anterior crura of the fornix at its fore part, and the joining or middle part of the choroid plexuses of the lateral ventricles at its back part, and that its middle part is over a passage downwards, named the iter ad infundibulum, or vulva †, which should rather be called iter ad tertium ventriculum.

When we afterwards carefully raise, and turn backwards the body of the fornix ‡, we find that the choroid plexuses of the lateral ventricles are connected together by a broad vascular membrane, which adheres closely to the fornix above it, and to the thalami nervorum optico-rum below it. Hence, too, this membrane covers and shuts the hole called Anus, and prevents

* See Tab. III. Fig. 1. and 2. F. See also Tab. IV. Fig. 1. and 2. F. F. and Tab. II. S.

† See Tab. III. Fig. 3. F. and Tab. IV. F. 3. F. 4. F.

‡ See Tab. IV. Fig. 3.

vents the lateral ventricles from communicating with each other, or with the third ventricle, at any place but that before described. In this membrane two large veins H H may be observed, which, farther back, unite to form a vein known to Galen, and named after him. Two small veins on each side of the brain, one from the septum lucidum, the other from the corpus striatum, run upon the upper and posterior edges of the hole by which the lateral ventricles communicate*, and terminate in the veins H H.

Under this vascular membrane, the extent of which, and the degree of its adhesion to the fornix and thalami nervorum opticorum, have not been sufficiently attended to, I find the thalami, even in children, inseparably united by medullary matter. Under the accretion of the thalami, and between them and the subjacent crura cerebri, the middle part of the third ventricle is situated. From the third ventricle a passage, universally well known, leads to the fourth ventricle, or calamus scriptorius †, which is placed between the tuber annulare, with the medulla oblongata on the fore part, and the cerebellum, with the valvula Vieussenii and nates and testes behind; so that this ventricle ought to be considered as a ventricle of the cerebellum, rather than of the brain.

The bottom of the fourth ventricle has no such communication with the cavity of the spinal marrow, as Dr Haller supposed, being completely shut by its choroid plexus and pia mater ‡.

In farther proof that the four ventricles communicate with each other, and that they do not communicate with the cavity of the spinal marrow, I have observed, in the bodies of every one of fifteen children who died from

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internal

* See Tab. III. Fig. 1. and 2. Tab. IV. Fig. 1. and 2.

† The substance called Pineal Gland, which is over this passage, is evidently a cineritious tubercle, from which medullary matter is sent out.

‡ See Tab. II. h. and Tab. VI. L.

internal hydrocephalus, that all the ventricles were distended; that, on cutting into one of the lateral ventricles, all the ventricles were emptied; that, in these cases, the passages above described were greatly enlarged*, and that, in none of them, water was contained in the cavity of the spinal marrow, or between its pia and dura mater.

If cases have occurred, such as Dr Haller quotes, in which both lateral ventricles were not emptied of water on opening one of them, the natural communications must have been shut, perhaps, by a degree of previous inflammation and its consequences.

S E C T. II.

IN the chronic species of internal hydrocephalus, where the head is enlarged by water within the ventricles, some surgeons have proposed, and, indeed, ventured to discharge the water by a puncture with the trocar †.

But, in two or three cases, where children had died from a great collection of water within the ventricles, I have observed, that, when the brain collapsed after cutting into one of the ventricles, some part of the septum lucidum was lacerated by the weight of the brain, or of the water in the opposite ventricle, which did not readily enough escape by the natural communication. So that, upon the whole, if we properly consider the various dangers which must arise from the puncture of the brain and the laceration of the septum between the ventricles; from the unequal bending and pressure of the parts when the brain collapses; from the admission of the air to the surface of the brain, which cannot well, or at all be prevented, because the bones cannot, by the application of a bandage, be brought to yield inwards, so as to be adapted exactly to the shape of the brain, such proposals will appear improper in the highest degree.

S E C T.

* See Tab. III. Fig. 4. 5.

† Mr L'Cat, Phil. Tran. vol. 47. Art. 40. p. 267.

S E C T. III.

IF, indeed, the water is situated between the dura mater and surface of the brain, and of course between the spinal marrow and its sheath from the dura mater, a case which, I believe, occurs more rarely than is generally supposed; or if, from a very evident fluctuation, chiefly about the bregma, we strongly suspect this to be the case, it will perhaps be adviseable to give the patient the only, though small, chance of cure by operation.

In one case of a boy of three years of age, whom I visited in 1764, along with Dr Grant and the late Dr Whytt, the head was greatly enlarged, with all the ordinary symptoms of hydrocephalus. Dr Whytt, who had seen several patients killed by a few ounces of water within the ventricles, and had never seen the head sensibly enlarged by water lodged in the ventricles *, insisted that the water must be situated on the outside of the brain; and, as I could not prove what I supposed, that it was within the brain, it was agreed that a surgeon should be called, and a puncture made. We asked Mr James Rae to attend, and I proposed that the puncture should be cautiously made, not with a trocar, but with a lancet, at the outer side of the bregma, as far as possible from the superior longitudinal sinus. The skin being accordingly first cut, and then the dura mater, and a probe introduced, without discharging water, we desisted from making any farther attempt.

The puncture soon closed, and the child survived three months. After death, I opened the head, in presence of Dr Grant, and several other gentlemen. We drew from the ventricles above two pounds of water; and, on examining the communication between the lateral ventricles, it was
found

* See Dr Whytt's Works in 4to, p. 728. Note †.

found to have nearly the size and shape of a similar case, sketched from memory, in Tab. III. Fig. 4.*.

C H A P.

* In 1764, December 13. I read to the Philosophical Society of Edinburgh, ' a paper on the communication of the ventricles of the brain with each other, and on their supposed communication with the medulla spinalis, with some remarks on the hydrocephalus and spina bifida, and on tapping in these diseases, illustrated with figures.'

This was referred to Dr Whytt, in order that he might report concerning it to the Society.

In this paper all the above circumstances were mentioned, and, for upwards of eleven years before that time, to wit, from the 1753, I had demonstrated the communications I have described in the Anatomical Theatre.

By an accident, I have in my possession a note taken by Dr Morgan, now physician and professor of physic in Philadelphia, from my lecture on this subject in 1762. The Doctor, who was then a student in this place, wrote an account of what he had seen, in that and the preceding year, to Sir John Pringle at London; and, lest he should have misunderstood what I had delivered, sent me a scroll of the letter he intended to send to Sir John. He chose to write in Latin as an exercise in that language.

Edin. Dec. 28. 1762. Hanc epistolam tibi mittere distuli, postquam eam huc usque scripseram, ut alia fruar occasione videndi ventriculorum commercium superiorum in schola hac anatomica, a nostro Professore Monro filio, demonstratum: Et quoniam hoc clare et perspicue factum est, descriptionem ejus nunc subijciam, ipsissimis quibus ille sententiis, quousque possum, utens.

Inquit, ' Anni decem nunc elapsi sunt a quo communicationem mutuam inter ventriculos cerebri laterales observavi, et methodo sequente illam describere solitus sum, quam, praetermissis cerebrorum fanorum sectionibus, in quinque hydrocephalo mortuis etiam vidi.

' Infra corporis partem anteriorem fornicis, inter crura ejus anteriora et flexum quem plexus choroideus, transeundo a tertii ventriculi summo in ventriculos laterales, facit, foramen est natura efformatum, quod in hydrocephalo ita auctum vidi ut digiti apicem caperet. Dum per hanc viam ventriculi laterales cum se invicem communicant, manifestum est eos, subter foramen illud, identidem quoque cum tertio ventriculo communicare,' &c.

C H A P T E R V.

Of the Absorbent Vessels of the Encephalon, and of the
Infundibulum and Glandula Pituitaria.

S E C T. I.

ALTHOUGH no late and accurate author has pretended to describe valvular lymphatic absorbent vessels in the brain of man or quadrupeds, yet there is no just ground for doubting of their existence.

1. In the *first* place, it does not appear that any person has attempted, by proper experiments, to discover them in living quadrupeds; and, although they had, as their trunks must be situated at the under part of the brain, they could not well have been brought into view.

After death, it is so very difficult to find the lymphatics in many of our organs, that the argument of their not existing, because they have not been described, will have most weight with those who are least versant in such researches.

2. As the lymphatic vessels are known to enter into the texture of almost all our other organs; and as, by attending to diseases, I have seen evidence that they exist in the eye, and within the cavities of the bones and joints, where no author pretends to have traced them with the knife, it would surely require some more powerful argument than any which has hitherto been employed, to persuade us, that, within the head, absorption is performed in a way quite different from what takes place in the rest of the body.

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3. In

3. In fishes, and particularly in the skate, I have injected wax, coloured with vermilion, from a lymphatic trunk, into so many small branches on the pia mater of the brain, the membranes of the eyes, and organ of hearing, that those parts were made quite red, and yet there was not a drop of the injection in the arteries or in the red veins.

4. If, to these arguments, we add, that the lymphatic glands of our head and neck are larger and more numerous than, comparing them with the axillary and inguinal glands, we can suppose to correspond with the outer side only of the head, and that they are disposed in a chain, the top of which is at the base of the cranium, it cannot be doubted, that future attention to those diseases, in which acrid matter is collected within the cranium, or that proper experiments, made on living quadrupeds, with coloured or strong scented substances poured into the cavity of the cranium, or accurate dissection, after tying up the lymphatics in the neck, will fully establish the proof, that absorption within the head is in all animals performed, as elsewhere, by the lymphatic system.

S E C T. II.

ONE other curious point of Physiology, connected with the above, remains to be determined, to wit, What becomes of the fluid which the infundibulum conveys to the upper surface of the Glandula Pituitaria? for that the infundibulum in man and quadrupeds is not a solid imperforated body, as several eminent authors contend*, but is a hollow membranous tube,

* Vieussens, Neur. Lib. 1. cap. 6. De Infundibulo, pag. 49. Nec id fenili meatu, secundum totam extensionem suam, donatum appareat.

Lieutaud, Anat. Hist. Lib. 5. p. 341. La tige qui s'élève de la glande pituitaire n'a point de cavité, comme on le pretend. Anat. Prat. p. 627.

Petit, Ed. de l'Anat. par Palfin, Tab. 2. p. 361. L'Entonnoir, ' Je suis du sentiment, de M. Lieutaud.'

tube, painted with many vessels, I am well assured by repeated experiments*.

In man and in the ox, I have repeatedly injected quick silver, or spirit of turpentine, coloured with vermilion, from the third ventricle, into the infundibulum, or I have put the pipe into the infundibulum, and tied it in with a thread.

In two such experiments on an ox, a number of small vessels in the substance of the glandula pituitaria were injected; but then I had pushed the injection with so much force that the infundibulum burst. In all my other experiments, the injection did not penetrate that gland, nor did it enter the veins or sinuses of the fella turcica, nor the valvular lymphatic vessels. I, therefore suspected, that, in the two seemingly successful experiments, the injection had filled vessels which naturally are not continued from the infundibulum, but that, after the vessels on the coats of the infundibulum were lacerated, it had got into them, an event that often happens, and has given occasion to many mistakes. Upon the whole, however, considering that all the ventricles of the brain communicate with each other; that the infundibulum is a hollow tube, connecting those cavities to the glandula pituitaria; that this gland, especially in an ox, resembles very much, in colour and consistence, the lymphatic glands; that the lymphatic vessels, when they reach their proper glands, divide within them into exceedingly minute

Haller, *El. Phys. Lib. 10. S. 1. p. 58.* ‘Num cavum fit infundibulum dubitari potest.’

S. Th. Soemmering *de Bas. Enc. et Orig. Nerv. 1778*, after many arguments and experiments, concludes concerning the infundibulum as follows: *Sed haec de infundibulo sufficient.* Quibus omnibus, absque partium studio, rite mecum perpensis, non potui non amplecti virorum illorum sententiam, qui infundibulum, si non perfecte solidum, certe non conspicuo, uti veteres opinati sunt, canali perforatum esse censuerint; *Lib. 2. § 2. p. 60.*

* See the cavity of the infundibulum delineated in the human subject, *Tab. II. at the letters U. V.* And *Tab. V. K.* In the sheep, *Tab. IX. Fig. 2. H.* And in the ox, *Tab. IX. Fig. 9.*

minute branches, far more so than has been conceived by anatomists, there seems to be reason for supposing, that the glandula pituitaria performs an office similar to that of a conglobate gland.

This opinion will appear still more probable, if further experience shall confirm what Petit has alledged, to wit, that, in hydrocephalus, he had found the glandula pituitaria scirrhus. From my own observation, I should conclude, that scirrhi of that gland happened rarely, as I found it to appearance found in twelve cases of hydrocephalus.

This last remark does not prove that its office is not such as I have supposed; for we often see dropsy of other parts, the lymphatic glands of which are in a sound state.

C H A P T E R VI.

Of the Use of the Ventricles of the Encephalon.

TO the conjectures proposed by authors, few of which are satisfactory, I have only to add, that the ventricles serve to increase the surface of the pia mater, and that, whatever purposes are served by that membrane and its vessels on the surface of the brain, we must suppose the same performed by it within the ventricles.

When we attend to the colour of the inside of the ventricles, we find the corpora striata cineritious, but almost all the other parts are white or medullary. Within the portions which are medullary on the surface, we, however, find cineritious matter, as within the thalami nervorum optico-rum and fornix.

CHAPTER VII.

Of the Cineritious and Medullary Substances of the Brain and Cerebellum.

SECTION I.

THE brain and cerebellum, after the investing membranes are removed, seem to consist of two substances, differing in colour and consistence, called Cineritious and Medullary.

The cineritious matter is softer than the medullary, and, in it, regular strata or bundles of fibres are not observed.

On the surface of the brain and cerebellum, many minute vessels pass from the pia mater into the cineritious substance; but the most successful injection is far from showing, as Ruysch and others have pretended, that it is entirely composed of vessels. Yet, I have not, in any animal, observed in it regularly shaped bodies which might be supposed glandular.

The cortical cineritious matter is somewhat, but not much, darker coloured on the outer than upon the inner side, where the medullary is joined to it, or the one does not evidently appear to be gradually converted into the other. It may not, however, be improper to observe, that the cortical, vascular, and internal uriniferous parts of the kidney seem, to the naked eye, the one to end, and the other to begin, almost as abruptly.

SECTION II.

BESIDE the cineritious matter observed in the cortical part of the brain and cerebellum, or on the surface of the corpora striata, a great deal of it
is

is to be found inclosed within the medulla. For, as we constantly observe, that such parts as are cineritious without, are medullary within; so we may invert the proposition, and remark, that, if any tubercle is medullary on the outer side, we shall, for certain, find cineritious matter within it. Nay, in the middle substance of the brain and cerebellum, half way between the surfaces of these and their ventricles, and even within the crura cerebri and crura cerebelli, or the tuber annulare and medulla oblongata, which are generally considered as pure medullary cords, I have found a great quantity of cineritious matter, into which, after a good injection with vermillion, I observe many vessels penetrate, so as to make the deep seated cineritious matter as red as the cortical*. The numerous vessels, therefore, which have been observed to penetrate the medulla, serve, beside, perhaps, some of the uses conjectured by authors, 1st, To supply the deep seated cineritious matter; and, 2^{dly}, In the cases of loss of substance of the cortex by wounds, or otherwise, the vessels which run from within, outwards, may not only furnish matter to nourish the deep parts, but also to supply the loss of the superficial, in the same manner as when a bone has exfoliated, the inner parts live, and the outer are, perhaps, in part supplied by the vessels which run from the canal of the marrow, outwards, through the tables of the bone.

C H A P.

* See Tab. VII. Fig. 1.

CHAPTER VIII.

Of the supposed Origin or Formation of Nerves.

S E C T. I.

FROM the under parts of the brain and cerebellum the nerves of the head and spinal marrow are commonly said to originate, and when we attend to the ideas of authors, we shall find,

In the *first* place, that many write as if they conceived that the whole medullary substance of the brain and cerebellum was employed in the formation of the nerves of the head, and of the spinal marrow*.

In the *second* place, that, very generally, the brain and cerebellum are conceived to be absolutely necessary to the formation of nerves; and, indeed, most authors have considered the brain as a gland, and the nerves as the ducts of that gland.

In the *third* place, the nerves are universally supposed to receive the whole energy by which they operate, from the brain, cerebellum, and spinal marrow.

But every one of these opinions, on very important points, will, perhaps, be found doubtful or erroneous when we consider them fully.

S E C T. II.

WITH regard to the first opinion, when in any animal, in man suppose,
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* Haller, Pr. Lin. 356. Medulla *omnis* cerebri et cerebelli per diversa foramina cranio exit, ad locos destinatos. Minores fasciculos nervos vocant, majorem medullam spinalem.

we make an horizontal section of the brain, where its hemispheres are joined together by the corpus callosum, we divide a mass of medullary substance, which is one hundred times, at least, as bulky as all the nerves of the head and spinal marrow conjoined. So that, unless we are to conceive that a hundred medullary fibres of the brain concur in forming a single nervous fibre, we must conclude, that a great part of the machinery of the brain serves some other purpose.

Besides, it may be observed, that many medullary fibres of the brain appear, from their direction, better calculated to connect the different sides and different parts of the brain to each other, than to connect the brain to the nerves. Thus, we observe transverse bundles of fibres in the corpus callosum, the commissura cerebri anterior et posterior, the tuber annulare, and even in the medulla oblongata*.

Further, it is obvious, and has been long and repeatedly observed by anatomists, that fishes, and other animals with very small brains, feel as acutely, and exercise their muscles as violently, as the other classes of animals in which the brain is proportionally much larger.

In the *last* place, the human brain so greatly exceeds, in proportional size, the brain of the other animals of the same class, that I have found the brain of a large ox not to weigh more than one fourth part of the human brain, whilst the weight of the ox was, probably, six times greater than that of the man; or the brain of the man was, in proportion to his weight, twenty-four times heavier than that of the ox †: At the same time, the nerves of the muscles of an ox are, in their size, proportioned to the bulk of his muscles; and those of the organs of his senses, as of the eye and nose, are proportioned to the extent of these organs; thus, the olfactory nerve of an ox is many times larger than that of a man. Hence we are led to con-

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sider

* See Tab. V. and Tab. VII.

† See similar experiments made by Dr Haller and others, *El. Phys.*

fider the brain as a medium between the mind and the rest of the body of the animal, by the intervention of the machinery of which the intellectual powers are influenced, in a way we neither do, nor, probably, ever shall be able to comprehend: And that, in man especially, a small part only of it is lengthened out, so as, in the common way of speaking, to give origin to the nerves.

S E C T. III.

NAY we may, perhaps, go a step further, and doubt whether, instead of considering the brain as the origin of the nerves, we ought not to consider it merely as connected with the nerves; or whether there are better reasons for supposing the brain to produce the nerves, than for supposing the nerves to produce the brain. Some facts, at least, may be here observed, which seem to show that the nerves may exist independent of the brain.

1. In children delivered at the full time, plump and well formed in their trunk and limbs, I have observed the substance which supplied the place of the brain not more bulky than a small nut, and, instead of containing a white medullary substance, it was of a red colour resembling a clot of blood: And small cords, occupying the place of the optic nerves, were likewise of a red colour. Yet the spinal marrow, and all the nerves from it, had the ordinary size and appearance. *

2. In a monstrous kitten, with two bodies and the appearance of one head, I found the spinal marrow of one of the bodies connected with a brain and cerebellum of the common shape and size. But the spinal marrow of the other body, though equally large, had only a small button of medullary substance at its upper end, without a suitable brain or cerebellum †.

3. In living frogs, I have repeatedly cut across the spinal marrow, or the trunk of the sciatic nerve, and fed the animal for upwards of a year thereafter.

* See Tab. VIII. and Tab. VIII. *

† See Tab. XII. Fig. 3. 4.

after. In some of them, the sciatic nerves were rejoined; but in none of my experiments did the nerves under the incision recover their powers; yet the nerves under the incision seemed, at the end of that period, as large in the limb in which the experiment was made, as they were in the sound limb*.

Whilst these facts seem to prove that the nerves may exist without the brain, and that they are not to be considered, according to the common idea, as being merely ducts which convey a fluid from a gland to distant parts, they seem also to show, that there is an energy of the nerves, independent of the energy of the brain; and, therefore, lead us to attempt to prove more fully that the nerves possess such an energy, and to discover the structure on which the possession of the energy depends.

Here let us begin by directing our attention to the structure of the spinal marrow.

C H A P.

* See Tab. XIV. Fig. 1. 2.

CHAPTER IX.

Of the Structure of the Spinal Marrow.

SECTION I.

THE spinal marrow, like the nerves of the head, seems to derive its origin from, or to be a continuation of the medullary substances of the brain and cerebellum, and may be considered as the largest nerve of the body. We shall find that it is divided, behind as well as before, to a greater depth than we would suppose from the descriptions given by late writers, so as to be composed of two cords, joined together at their middle or deepest parts by a lamella, which consists chiefly of red vessels and cineritious matter*.

Nay, when either of these two cords is accurately examined, it will be found to be subdivided by a slight furrow, into a small posterior cord and large anterior cord. In the former, fasciculi of longitudinal fibres readily appear; in the latter, the disposition of the medullary fibres is much less evident.

In the medulla oblongata, considerable vessels pass from the anterior rima or calamus scriptorius to the posterior fissure; and hence the two cords seem to be joined by transverse fasciculi of the medullary fibres†; but in the spinal marrow these vessels are small, and the joining of the two principal cords seems to be made by a thick plate of cineritious substance. When we cut the spinal marrow transversely, the internal cineritious substance makes

* See Tab. VII. Fig. 2. And Tab. IX. Fig. 4. 5. 6. 7. 8.

† See Tab. V. Q. Q. And Tab. VII. M. N. O.

makes a cruciform appearance, or consists of four portions, one corresponding to each of the four cords of which I have observed it consists*.

The surface of the spinal marrow, which is covered with the pia mater, has been described as a pure medullary substance†; but, although it has a great deal of the medullary matter in it, yet if, in a recent large animal, as the ox, a transverse section be carefully examined, the outer layer will be found to contain a considerable quantity of cineritious matter, or the spinal marrow also will be found to have cineritious cortical matter under its pia mater, and, in general, to agree with the brain in its structure.

S E C T. II.

BETWEEN the anterior and posterior bundles of fibres which form the spinal nerves, a ligament is connected, by a number of threads, to each side of the pia mater of the spinal marrow, through its whole length, for its support, of which, as no sufficiently accurate description or figure has been given, I have had a drawing made‡. As this ligament is fixed, by a number of teeth, to the inner side of the sheath, formed by the dura mater, it has been called Denticulatum. The greater number of these teeth run transversely, some ascend, others descend||, all split into fibres, which are incorporated with the fibres of the inner layer of the dura mater. From the conical under end of the spinal marrow, a cord is produced**, which reaches to the os coccygis, and there splits into threads, which may be considered as the termination of the last teeth of the ligamentum denticulatum.

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S E C T.

* The cruciform appearance of the cineritious substance of the spinal marrow was known to Blasius and a few other writers, as Huber, &c.; but as they did not remark, that each side of the spinal marrow is subdivided into two columns, the cause of the cruciform appearance was not understood by them.

† *Natura medullae spinalis est, quam vox declarat, medullaris omnino, maxima certe parte sui, et externa tota facie.*

‡ See Tab. X. Fig. 1.

|| See Tab. X. Fig. 1. a. b.—x.

** See Tab. X. Fig. w. x.

S E C T. III.

WHEN we carefully trace the anterior and posterior bundles which form the spinal nerves, we shall find that each has its proper hole in the spinal sheath of the dura mater; and from the inner layer of the dura mater its proper sheath, or that, between the two bundles which form the spinal nerves, a portion of the dura mater intervenes*. On the outer side of the spinal sheath of the dura mater, the cellular substance condensed, ties the two bundles together, so that, at first sight, they appear like one nerve. Hence authors have described them as passing through one hole†, and as forming one nerve terminating in a ganglion‡. But, when we break the cellular substance which connects the two bundles, it will be found that the posterior bundle only ends in the ganglion; and that the posterior bundle has not its nervous fibres incorporated with those of the anterior bundle till it has passed through the ganglion||.

S E C T. IV.

ANOTHER memorable circumstance also, entirely overlooked by most authors, and not properly delineated by a few who have observed it§, is, that the posterior bundles of all or most of the cervical nerves, for there is a variety in different persons, detach small bundles of nervous fibres to the posterior bundles of the nerves above or below them**. In some persons I have found a few fibres detached, in like manner, from some of the posterior bundles of the dorsal nerves.

S E C T.

* See Tab. X. Fig. M. and T.

† Haller, Pr. Lin. § 361. El. Phys. L. x. p. 239.

‡ Blasius, Tab. VII. An. Comp.—Bidloo's Tab. X. Fig. 4. F.—Huber, v. Haller, Fasc. An. Tab. 3.—Haller, El. Phys. L. x. p. 240.

|| Tab. X. Fig. 1. N. O. P. Q. and Tab. XI. N. O. P.

§ As Huber and Haller. See Haller Fasc. An. 1. Tab. III. and F. An. 7. Tab. IV. and V.

** See Tab. X. Fig. 1. V. W. X. Y. Z.

S E C T. V.

BEYOND the ganglia, or after the anterior and posterior bundles of nervous fibres are intermixed, the external anterior and posterior branches of spinal nerves are detached, and, at the same places, connections are formed with the great sympathetic nerves *. The nature of which I shall afterwards attempt to explain.

S E C T VI.

IN like manner, the accessory nerve, which comes out behind the ligamentum denticulatum, takes its rise partly from the side of the spinal marrow, and partly, by filaments, is connected to the posterior bundle of some of the spinal nerves †.

C H A P.

* See Tab. X. Q. R. S.

† See Tab. X. Fig. 2.—Winflow, S. 6. § 143.—And Haller, El. Phys. L. x. S. 6. p. 242.
make mention of filaments added to the accessory, from the posterior branches of the cervical nerves.

CHAPTER X.

Of the Pia Mater, the Colour and Texture of the Nerves.

S E C T. I.

ALTHOUGH the nerves have been universally considered as a continuation of the pure medullary substance of the brain and cerebellum*; yet I find, on accurately examining them, that, with a few exceptions, particularly of the optic nerves and portio mollis of the auditory, they are all of a browner colour than the medullary substance, their pia mater seeming to furnish a quantity of cineritious matter. As a farther proof of this, they are larger in their course than at their supposed origin.

This difference of colour and increase of bulk is more remarkable in the nerves of the spinal marrow, especially those that form the cauda equina, than in the nerves of the head.

S E C T. II.

THE optic nerves and portio mollis of the auditory seem, indeed, from their bright white colour, to receive from their pia mater little or no cineritious matter in their progress to the eye and ear; but as soon as they enter these organs, to form the retina and to be spread out on the membrane of the cochlea and semicircular canals, instead of remaining white and opaque, they become cineritious: The cause of which is, that, contrary to what has been alledged by all authors, they carry with them their pia mater, and from that membrane every fibre of the nerve receives cineritious matter.

S E C T.

* Haller, El. Phys. Tab. IV. Index, p. 581. 'Nervi continent medullam cerebri et similes sunt striis pure medullaribus cerebri.'

S E C T. III. .

IN like manner, I have observed the nerves in the ear of fishes, which terminate on the semicircular canals, and in the sac which contains a cretaceous substance and viscid humour; become very suddenly pellucid. The same thing may be observed with respect to a large nerve of the skate, which terminates on the beginning or centre, from which I have found the cutaneous mucous ducts issue.

In all these instances, the change of colour is not entirely, nor chiefly, owing to the white medullary substance dividing into its constituent threads and becoming thinner; for, if the optic, or any other nerve, is bruised and spread out thin upon a plate of glass, into an equal extent, it still appears white and opaque. Some cineritious, or other matter, seems, therefore, to be added, which changes the colour, and renders the nervous matter more pellucid.

Without admitting that the pia mater accompanies the medullary matter of the retina, or portio mollis of the ear, how are we to suppose the accompanying blood-vessels to be supported? how are we to explain the difference of their colour, or the greater bulk and greater toughness of them than of the pure medullary matter sent off from the brain, cerebellum, and spinal marrow?

S E C T. IV.

If a nerve was merely a production of the medullary substance of the encephalon, without receiving the addition of new matter in its progress, and if its pia mater could add nothing to it of nervous matter, we should find the nerves of a living animal, under an incision of them, shrink greatly in a short time, as an absorption is going on continually in all the organs of an animal. Instead of which, I have not observed, a year after cutting the

I

trunk

trunk of the sciatic nerve in a living frog, that the lower part of the nerve was sensibly diminished in its bulk.

S E C T. V.

I HAVE found, after the sciatic nerve had been cut, and the member was insensible and motionless, that the circulation of the blood remained, for a year thereafter, rapid and free in the hind leg of a frog; nay, that, when I had broken the bones and wounded the flesh, an inflammation was excited; and, at last, the wounds were closed with new matter, and the broken bones reunited. Yet we have the strongest reasons for believing, that the small vessels, in circulating the blood, in inflammation, and in the production of new matter, are actuated by a nervous energy, which, in the cases before us, could only have been furnished to the nerves by the vessels of the pia mater which incloses them and the cineritious substance it produces.

S E C T. VI.

AMONGST other experiments I made, of which I read an account to the Philosophical Society of Edinburgh in 1761*, I found, that, when I poured a solution of opium under the skin of the thigh and leg of a living frog, not only the leg itself was very soon affected, but the affection was communicated to the most distant organs of the body, by a sympathy of the nerves; but if, previous to the application of the opium, I cut out the heart, or cut across the femoral blood-vessels, the effects of the opium were not communicated from that limb to distant parts, which proves that the arteries accompanying the nerves, or the arteries of the pia mater of the nerves, have great effect in fitting the nerves to receive and to communicate impressions.

C H A P.

* See Edinburgh Phil. and Liter. Essays, Vol. 3. Art. 13. Exper. 6. and 9.

C H A P T E R X I.

Conclusions drawn from the Three last Sections.

WHEN we review the three last sections, there appear to be just reasons for believing, that a small portion only of the brain, especially of the human, is elongated in order to form the nerves and spinal marrow.

2. That the rest of it, as a medium between the living principle and the other parts of the body, performs offices which are proper to it.

3. That the opposite sides of the encephalon are joined by bundles of fibres, so that we seem, in a certain degree, to perceive the cause of the suffering of all parts of the nervous system with that of any one part of it, or of the general sympathy of nerves.

4. We have observed, that the right and left sides of the spinal marrow are divided from each other by deeper fissures than have been described by many late writers, or that the right and left sides of it are less intimately connected than is commonly imagined. From attention to this circumstance, we are, in some degree, enabled to explain the cause why one side of the body is much palsied, whilst the other preserves its powers unimpaired, or to understand the cause of hemiplegia.

5. We feel and can act with our muscles only when the brain and the nerves of the organs employed are connected together. But, for the reasons given in last section, I have long thought and endeavoured to prove, that our nerves, independent of the encephalon, possess an energy or principle of life, which they derive from their proper pia mater and its vessels: Or that the limb of a frog, in which the circulation continues, after the
sciatic

sciatic nerve has been cut, has its minute vessels actuated by an energy which may, strictly speaking, be called nervous, and which seems to be analogous to the energy which operates on the parts of those animals, for instance, the *echinus marinus*, in which I have not found any organ resembling our brain, or is, perhaps, like to the energy by which the parts of the vegetable kingdom are actuated.

6. In consequence of this idea, we should, in palsy, and other diseases of the nervous system, not confine our attention entirely to the state of the encephalon, the supposed sole origin of the nerves, but ought to attend to the state of circulation in the limbs affected.

C H A P T E R XII.

HAVING considered the general texture of the brain, cerebellum, and spinal marrow, and endeavoured to show that the nerves are not only covered with the pia mater, but that it furnishes to them, in their whole progress, a nutritive substance and nervous energy; and further, that the pia mater is not laid aside in the retina, or within the cochlea, nor at the extremities of the nerves in general, as has been universally supposed by authors, I shall proceed to give a particular description

Of the APPEARANCE of the NERVES in their COURSE;

Of the NATURE of their PLEXUSES;

Of the STRUCTURE of NERVOUS GANGLIA;

Of certain SPHEROIDAL BODIES connected with the BRAIN and NERVES
of some ANIMALS.

CHAPTER XIII.

Of the Appearance of the Nerves in their Course, and particularly of their Folds or Joints.

A Person who has read in authors that the nerves are the continuation of the medullary substance of the brain, cerebellum, or spinal marrow, collected into cords, which consist of longitudinal fibres laid parallel to each other, will be far from finding the appearance of them to correspond with his idea.

I have already observed, that, with a very few exceptions, the nerves are not white, like the medulla, but of a cineritious colour, and that they are not to be considered as pure medullary cords.

I will now add, that when, in any of the four classes of large animals, we view the nerves carefully with the naked eye, or with a common magnifying glass, they appear to consist of a semipellucid substance, in which a more white and opaque fibrous looking matter seems to be disposed in transverse and serpentine lines*.

This appearance is so remarkable, and so evident in all the nerves, especially in the small ones, where the external coats are thin, that, whoever will examine it, must be astonished that no notice has been taken of it by any author †.

When

* See Tab. XIII. Fig. 1. to 14.

† The only person who, before me, had remarked, in a transient way, an appearance of serpentine or spiral fibres in a nerve, is the very learned Dr Thomas Smith physician at Birmingham. In the year 1767, whilst he was engaged in composing a very excellent Inaugural Dissertation, which he published, *De Actione Musculari*, he told me he had seen an appearance of spiral fibres in the sciatic nerve
of

When the nerve is fully relaxed, these serpentine transverse lines are best seen. When the nerve is moderately stretched, they are much less evident. When the nerve is greatly stretched, beyond what it ever is in a living sound animal, it appears uniform in its colour and consistence*.

Hence these lines are, in the *first* place, to be considered as folds or joints in the nerve, and may be compared to the lines in the palm of the hand, serving to accommodate the nerve to the different states of flexion and extension.

To prove, still more clearly, that this is their chief use, I observe, that the tendons of all animals have a similar appearance, in their relaxed state; but lose that appearance when they are greatly stretched†.

By attending to this appearance of the nerves, I have, with certainty, traced their small branches, when I could not, by any other mark, have been able to distinguish them.

These folds or joints appear in the nerves between the brain and foramina in the cranium, or before the nerves reach the dura mater; and they appear distinctly in the nerves, in their whole course, on the outside of the head: Nay, contrary to what might have been supposed, they are nearly as
numerous

of a young crow. He had formed no opinion of the nature or use of these fibres; and he supposed them proper to that species during their growth.

The following year, I procured, in the evening, a young crow. I cut off its hind legs, and put them into a basin full of water till next morning: But I could not then observe any such appearance as Dr Smith had described. I supposed, therefore, that there had been some mistake in that matter; and I did not observe such an appearance in the nerves till many years afterwards, when I remarked it first in a skate fish. By soaking a nerve in water this appearance is lost.

* See Tab. XIII. Fig. 1. 10. 11.

† See Tab. XIII. Fig. 15.

numerous and as distinct in the nerves within the head, or in the nerves which seem so fixed in their place as to be little subject to unequal extension, as the fifth pair is at the sides of the sella turcica, or the great sympathetic within the thorax, as they are in the nerves of the muscles. Hence they seem also intended to increase the surface of the nerves, and the extent of their pia mater.

The spinal marrow has likewise a number of transverse furrows or lines, which very evidently serve the purpose of joints or folds *.

C H A P.

* See Tab. XL L.

C H A P T E R X I V .

Of the Connection of the Nerves in their Course.

WHEN we consider the delineations given by authors of the manner of the connection of the nerves, we shall find three modes of it represented.

In the *first* place, nerves are represented joined together at acute angles, forming what have been generally named Plexuses.

Secondly, Nerves running in opposite directions, are connected by their small branches, or *apices* of these branches, forming net-works, which, at first sight, seem to resemble the anastomoses of small blood-vessels.

Thirdly, in certain places of the body, several nerves enter into a knot, called a Ganglion, and from the opposite side of the knot nerves are sent out.

The nature of these modes of connection we shall next examine.

CHAPTER XV.

Of the Plexuses of Nerves.

EVERY nerve of the spinal marrow is joined near its exit, by an arch, with the nerve above and below it: But the connection of the several nerves of the arm, or of the leg, may be considered as chief examples of plexus.

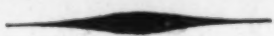
Eustachius, and several succeeding authors, have given pretty exact delineations of the outside appearance of these plexuses; but no author has either carefully traced the nervous fibres in their course through them, or properly explained the uses they are intended to serve.

Many years ago, I was at the pains of tracing the fibres of the nerves of the arm from their origin in the spinal marrow, to their termination in the parts of the arm, by flitting open the sheaths of all the trunks where they form the brachial plexus. I found, as, indeed, I expected, that in the plexuses, the fibres of the different trunks were intermixed, and that every nerve under the plexus consisted of fibres of all the nerves, which were tied together above its origin from the plexus*.

The joining of the optic nerves not only resembles, in its outside appearance, the joining of two of the cervical nerves in the brachial plexus, but it is impossible to separate them, without tearing the medullary cords; so that there appears to me no doubt, that the medullary fibres, from the two sides of the brain, are there intermixed. But as this nerve is more purely medullary than nerves in general are in their course, and softer, because

* See Tab. XV. Tab. XVI. Tab. XVII.

cause its component fibres are less separated by the intervention of the pia mater, it is much more difficult to trace its fibres from end to end, so as to demonstrate the fact clearly: But, unless I am much deceived, I have seen, in man, an intermixture and partial decussation of the cords which compose the optic nerves *.



C H A P T E R X V I.

Of the Connection of Nerves which run in opposite Directions, so as to be joined by their small Branches.

THE most remarkable connection of this kind is, in the human face, where the portio dura of the auditory nerve is joined to the second and third branches of the fifth pair of nerves.

Many of these nerves joined are so small, that it is very difficult to trace the fibrils of which they consist: But, in the larger branches, both in man and in the ox, I have certainly found, that the small branches which come off beyond the union of two larger nerves, consist of fibres from both †.

C H A P.

* See Tab. V. F F. G. H H.—Zinn de Oculo, p. 190. says, *Multa substantia medullari inter se cohaerent, ut tamen non misceantur.*

† See Tab. XIX.

CHAPTER XVII.

Of the Connection of the several Cords which compose each of the Nerves.

SECTION I.

AFTER finding, that, in the plexuses and net-works, the fibrils of different nerves were intimately intermixed, and that, almost all our organs, whether active or passive, received branches of nerves from various trunks, I was naturally led to investigate, whether the cords, into which the fibrils of the particular nerves are collected, run parallel to each other in a common sheath, without connection, so that their number is the same at the end as at the origin of each nerve, which we shall find is supposed by authors*; or whether these, in their progress, formed new combinations. I soon found, that, in the whole extent of the nervous system, the subordinate cords, of which the particular nerves consist, formed within their proper sheaths a succession of plexuses, in which their fibrils were intermixed and combined again, in nearly the same manner as in the axillary plexus formed by the trunks of the cervical nerves: Thus, when I slit open the sheath of the brachial nerve, called Radial, by my father, or Median by

* Haller, Elem. Phys. Tab. 4. L. 10. S. 6. § 3. p. 187. and 188. ' Nullus nervus adeo exiguus est ut non ex pluribus constet funiculis . . . hi funiculi . . . facile ostenduntur cylindrici aut aliquantum compressi, recti, fibique paralleli et similes, nusquam (si a gangliis recefferis) confusi, nusquam ramosi, sed ab ipso cerebro aut a spinali medulla, ad suum usque finem distincti, ut non plures in fine sunt quam in principio. Numerus eorum funiculorum iniri vix potest. Saepe centum in uno nervo Quinto sunt, in ischiadico plures.

' Deinde, si microscopium adhibueris, funiculi illi, qui nudo oculo simplices videntur, in minores alios discedunt,' &c.

by Winflow, which, after supplying various muscles, terminates in the thumb and three next fingers, instead of finding the same number of subordinate cords at the lower end of the nerve, which I found at its upper part, and, instead of finding that these were placed parallel and contiguous to each other, but unconnected, and that the outermost of them ended in the thumb, the next in the fore-finger, and so on, I found a very different number of subordinate cords at the upper and under ends; and the fibres of these cords were, in their whole course, so often separated from each other, then blended together, and afterwards combined into other cords, that each of the cords, at the lower end, seemed to have received fibrils from all the cords at the upper end*.

In like manner, I have discovered, in the ear, that the branches of the portio mollis form, upon the membrane and scala of the cochlea, a most elegant plexus; in which the nervous filaments are so intermixed as to form new combinations, so far as they can be traced with glasses, and seem at last to terminate in a retina or web, somewhat resembling that formed in the eye by the optic nerve†.

S E C T I I.

THE chief intention of Nature, in this very solicitous intermixture of the nervous fibrils, is, I apprehend, to lessen the danger with which accidents or diseases, affecting the trunks of the nerves, would, without these combinations, have been attended.

Thus, let us suppose that two nerves are sufficient to supply the flexors

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and

* See Tab. XVIII.

† I first traced the portio mollis on the membrane of the cochlea of an adult at Berlin, in the end of the year 1756. In Table XXX. see very accurate figures of this first preparation, which I have annually, since that time, demonstrated in my anatomical courses, and which several good judges have had the curiosity to examine with glasses, particularly Dr Soemmering, Dr Meckel junior, Mr Luther, Dr Smith from Oxford, Dr Rutherford, Dr Black, Dr Hutton.

and extensors of the fore-arm; it is evidently better for us, that the one half of each nerve goes to the flexors, and the other half of each to the extensors, than that the whole of the first nerve should have gone to the flexors, and the whole of the second to the extensors. For if, by accident or disease, one of these nerves should be cut across, or lose its powers, we should, on the first supposition, preserve one half of the power both of flexion and extension, which would surely be preferable to our possessing fully the flexion, without any power of extension.

If a still greater number of nerves is employed to supply the flexors and extensors, the loss of power, arising from an accident happening to one of the trunks of the nerves, will be felt in a much smaller degree; thus, in the arm, where five trunks are found, a fifth part only of the power would be lost.

S E C T. III.

1. NOTWITHSTANDING we have observed that the fibres of the nerves, in their course, are much more intimately intermixed than has been supposed, still, as their branches do not anastomose, there is little or no reason for believing that the energy of one fibre can directly affect that of a neighbouring or contiguous fibre, or that the sympathy of nerves can depend directly on their connection in their progress. We are, therefore, led to refer it, in the first place, to their connections in the brain, where we have found there are many more medullary fibres than are sufficient to form a bulk equal to all the nerves, and where, besides, many of the fibres seem evidently intended to connect opposite sides of the brain.

2. But although we cannot, from the intermixture of the nervous fibres in their course, account for their sympathy, but are obliged to refer the cause to their connections in the brain, in which the feeling principle is seated; yet, from finding that each small branch of a nerve is derived from various sources, we perceive, that an injury done to it may affect and irri-

tate

tate the brain in various and distant places, and, these reacting, we understand better how a suffering by sympathy may become extensive or universal, than we do, when we conceive that each nerve is derived from a single small portion only of the brain.

3. As different nerves, intermixed, are supplied by branches of the same artery, and that the arteries furnish pia mater and cortical matter to the nerves in their progress, and evidently influence their energy, it may be a question meriting attention, whether sympathy of nerves may, in some measure, depend on the irritation and reaction of their accompanying blood-vessels?

CHAPTER XVIII.

Of the External Covering of the Trunks of the Nerves, and of the Cords or Funiculi of which they consist.

THE trunks of the nerves are known to be covered and defended by a thick and strong membrane, which, in the optic nerve, is evidently the continuation of the inner part of the dura mater. The holes in the cranium, through which the other nerves of the head pass, are lined with the same membrane, and the inner part of it adheres to the nerve when it leaves the bone; the spinal marrow is inclosed in a loose sheath produced from it; and the inner part of that sheath adheres to the beginning of the spinal nerves, and evidently covers them for some way after they have passed out between the vertebrae. Hence the external covering of the nerves has been considered as the mere continuation of the dura mater.

But the very accurate Zinn has observed, that the continuation of the dura mater along the nerves in their course, is not to be traced so evidently as has generally been supposed; for, that the inner part of the dura mater, which incloses and adheres to the beginning of the nerves, is very thin, and soon degenerates into the common cellular substance. He, therefore, considers the external covering of the nerves as the cellular substance condensed.

But, although this opinion of Zinn is so far just, that the dura mater cannot, so evidently as is supposed, be demonstrated to form the whole of the external coat of nerves, it may be observed, that the external covering of the nerves, in their course, is almost as tough as the dura mater; agrees much with that membrane in its colour and fibrous texture, and, probably, in its properties; and cannot, as Zinn represents, be readily dissolved

folded into cellular threads. So that it will occasion no material error in physiology or pathology, whether we consider the external coat of the nerves in their course as the continuation of the dura mater, or as a cellular substance condensed, or as a coat proper to the nerves, created thick and tough, merely to preserve them from laceration and other injuries.

Authors, whether they suppose this thick and tough coat to be derived from the dura mater, or produced from cellular substance condensed, have represented it as giving a covering to the trunks only of the nerves, or to branches detached from them, and have described the smaller cords, or funiculi which compose the trunks, as covered by the pia mater only*. But, in by far the greater number of the nerves, and particularly in all those which run amongst and terminate in the muscles, I observe, that the funiculi, or smaller cords, have a similar tough, dense, fibrous coat, and within it the thin vascular pia mater.

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C H A P.

* Haller, El. Phys. Tab. IV. L. 10. S. 5. § 3. p. 188. 'Porro eorum funiculorum quilibet membranula ambitur, quam a pia mater esse, ipsa continuatio, in medulla spinali evidentissima, demonstrat. Naturam etiam teneram suam, atque vasculis punctam, ea meninx in nervis retinet.'

CHAPTER XIX.

Of the Ganglia of the Nerves.

S E C T. I.

I WOULD begin here with again observing an universal oversight of authors in their description of the ganglia of the spinal nerves. They describe these as formed after the anterior and posterior fasciculi of nervous fibres from the spinal marrow are united; so that every nervous fibre from the spinal marrow, is supposed to pass through a ganglion. Instead of this, I have observed, that the posterior fasciculus only of the spinal nerve enters into the ganglion; and that authors had been deceived, by not having slit open the external coat of these nerves*.

One half, therefore, of all the nerves of the muscular organs of the trunk of the body, and one half of the nerves of the arms and legs, do not pass through ganglia.

S E C T. II.

AUTHORS suppose that the olfactory, the optic nerves, the fourth, sixth, seventh, eighth, with its accessory, and the ninth pair, are without ganglia.

But, as the sixth pair, portio dura of the seventh, the eighth and the ninth pairs, are connected by nervous filaments to the ganglia of the great sympathetic nerve, we shall soon find that there may be some reason for supposing that part of them likewise passes through these ganglia, as we cannot pretend to judge of the course of the nerves from observing the angles they form with their trunks, the course of many nerves being retrograde.

S E C T.

* See Tab. X. N, O, P, Q. And Tab. XI. N, O, P, Q.

S E C T. III.

HOWEVER different from each other the ganglia seem in shape and size, in different parts, and although, in the progress of the great sympathetic nerve, the number, and, of course, the size of each, varies in different persons, I have found, after accurately examining the principal ganglia in man and in the ox, and particularly the lenticular ganglion of the eye, the ganglion in the trunk of the fifth pair*, the cervical, thoracic, and femilunar ganglia of the great sympathetic, the ganglion in the posterior fasciculus of the spinal nerves, that they all agree in their general structure, which I shall next describe, as it appears to the naked eye, or when viewed with a common magnifying glass.

In investigating this subject, I was enabled to trace the nerves in the ganglia, by attending to their folds or joints, when it would have been impossible, from any other circumstance in their structure, to have distinguished them.

I have already observed, that the nerves of an ox, or other large animal, are larger than the nerves of a man, although his brain be smaller. The size of the ganglia bears a proportion to that of the nerves.

In the *next* place, although the size of the ultimate fibrils of which the nerves are composed, is, perhaps, not larger in the ox than in man; and although, of course, the number of ultimate fibrils is in proportion to the bulk of the nerves; yet the funiculi, or cords into which these are collected, are larger in the ox. Hence I found, that I could trace the nerves farther and more distinctly in the ox than in man, and more easily and certainly discover the texture of the ganglia.

Authors

* This ganglion was described and painted by Ridley, An. of Brain, Fig. 3. And Cowper, Ap. to B. Fig. 27. but overlooked by most modern anatomists till of late, that the description of it has been revived by Gasserius and the accurate Dr Wrisberg, de 5to Par. 1777.

Authors have affirmed, that, in the ganglia, the straight course of the nervous fibres is interrupted. By this they mean, that a nerve cannot be traced from the place at which it enters the ganglion, to the place at which it comes out from it*. Hence, it is evident, that any description they have given of the manner in which the nerves divide, after entering the ganglion, of the course they pursue within it, or of the new combinations they form before they go out of it, must be considered as mere hypotheses.

I first examined the surface of the ganglia; and afterwards cut them, and the nerves entering or going out from them, longitudinally.

On the surface of the ganglion I could trace, distinctly, many of the nervous cords, from their first attachment to the ganglion, till they parted from it, without any substance intervening of a different texture from that of the nervous cords elsewhere†.

Where two or more nervous cords entered one end of a ganglion, and two or more were produced from the other end of it, I could plainly perceive, that the nerves, in their course upon the surface of the ganglion, after dividing into smaller, were again collected into larger cords, in such a manner, that every nerve that came out of the ganglion consisted of fibres from two or more of the nerves which entered into the ganglion‡.

In the ganglia, and nerves connected with them, which I had cut open length-ways, I could perceive, in every part of the ganglia, nerves distinguishable

* Dr Haller, in Pr. Lin. Phys. § 364. gives the following account of the ganglia, 'Duri nempe tumores nervei, incertae hactenus aut fabricae, aut utilitatis, in quibus fibrarum nervearum rectitudo interruptitur.'

† See Tab. XX. Fig. 3. Tab. XXII. Fig. 1. 2. 4. 5.

‡ See Tab. XX. and XXII.

guishable by their joints, which I could trace to or from the cords of nerves connected to the ganglia; so that the fibrous jointed texture, proper to the nerves in other parts of their course, was neither lost, nor changed, within the ganglia, into a substance quite different from nerve *.

The jointed fibres within the ganglia have, however, in their interstices, or seem covered and incruited by a quantity of hard substance, of a yellowish colour, in the ox, and in some of the human ganglia, as that in the trunk of the fifth pair, but rather of a reddish brown in the greater number of the ganglia in a man, upon which many blood-vessels are dispersed †.

S E C T. IV.

THE cords that come out from the under end of a ganglion are generally larger than those which go in to the upper end of it, as authors ‡ have remarked; thus, the nerves issuing from the femilunar ganglia, seem much more bulky than the rami splanchnici which go into them ||. But in the course of the sympathetic nerve we see, in some places, exceptions to this rule.

S E C T. V.

THE last, and not least remarkable, observation to be made concerning the ganglia, and nerves connected with them, is, that, although the greater number of nervous threads do, perhaps, run in the direction supposed by authors, that is, from the head downwards to the feet, yet every nerve connected with a ganglion, appears to contain cords, running in opposite directions, ascending, for instance, and descending. Or where nerves are connected to the upper, under, and outer part or side of a ganglion, which

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* See Tab. XX. Tab. XXI. Tab. XXII. Tab. XXIII.

† See Tab. XX. Fig. 1. 2. 4. Tab. XXII. Fig. 6.

‡ Mechel, M. de l'Acad. a Berlin, 1749. p. 95. § 19.

|| See Tab. XXII. Fig. 5.

is the case of the thoracic ganglia of the sympathetic nerve, the nerve at the side appears to consist of cords, which divide into ascending and descending cords, that are combined with the cords which compose the upper and under nerves*.

If branches, such as the rami splanchnici, are sent off from a ganglion in which such descending, ascending, and lateral, or transverse nerves meet, the branches seem to receive threads from all the nerves which enter the ganglion.

S E C T. VI.

FROM these several facts, I apprehend we may draw the following conclusions.

First, Several branches of the nerves, which enter a ganglion, run upon its surface, separating from each other, and joining again, so as to form new combinations of threads at the other end of the ganglion.

Secondly, When we cut a ganglion, we are so far from finding that the course of the nerves is interrupted within it, or that it is a substance totally different in its nature from the nerves that enter it, that we are able to trace, in every part of the ganglion, nerves distinguishable by such folds or joints as are seen in them in all other places.

Thirdly, In the substance of the ganglion, we see nervous cords leading from any one nerve, connected to the ganglion, to the greater number of, if not to all, the other nerves connected with it, from which we may conclude, that various other combinations of the nervous threads take place within it †.

Fourthly,

* See Tab. XX. Fig. 1. B. Tab. XXII. Fig. 2. 4. F. K.

† Zinn, M. de l'Acad. de Berlin 1753, p. 138. says, 'Il me paroît extrêmement probable,' that the nervous threads in ganglia are intermixed; but this opinion, with him and many others, was a mere hypothesis, not founded on actual observation.

Fourthly, It appears very difficult, in many instances, to distinguish all the nerves which enter a ganglion, from those which are sent off from it. And, of course, it is difficult, or impossible to determine all the sources from which any branch sent off from the ganglion is derived. For example, although the nerves at the upper end of a thoracic ganglion of the great sympathetic nerve are composed chiefly of descending branches, and, in like manner, the two nerves which tie it to the proper dorsal nerve, are chiefly derived from the dorsal, yet there seem to be ascending branches from the nerves below, and others sent outwards, from the ganglion, to the proper dorsal nerve; and, probably, the splanchnic nerves receive threads from all these sources.

Fifthly, The nerves which issue from ganglia seem, as authors* have alleged, to be more bulky than the nerves we may suppose to enter the ganglia; yet I have not been able to discover that the coats of the nerves going out were thicker, or different from the coats of the nerves going into the ganglia: Hence there is just reason to suppose, that nervous matter is furnished by the ganglia.

Sixthly, To strengthen the supposition that the ganglia are to be considered as sources of nervous matter and energy, I would observe,

That the yellowish or brownish matter of ganglia has numerous vessels conveying red blood, as in the cortical substance of the brain, dispersed upon it: That its colour, especially in man, very much resembles that of the cortical substance of the brain: That, in several children, in whom the brain had either been originally imperfect, or compressed by accident, its colour and consistence still more closely resembled that of a ganglion. As to the greater hardness of the ganglia than of the cortical substance, which,

to

* Meckel, M. de l'Acad: a Berlin, 1749, p. 95.

to Dr Meckel *, has appeared to afford sufficient reason for denying that they serve for secretion, that, I apprehend, will evidently appear necessary to defend them from external violence, or the pressure of the muscles and other organs.

To which I would add an observation on the first pair, or olfactory nerves, which seems to carry with it considerable weight, to wit, That, in man, the trunk of the olfactory nerve has, adhering to its end, a cineritious bulb, situated within the cranium, and which is evidently of the same texture with the cortical matter of the brain †. Now, in fish, I have found, that the olfactory nerve has no such bulb within the cranium; but when we trace that nerve forward towards the nose, which is, in them, at a great distance from the cranium, we find a ganglion, near the nose, which supplies the place of this bulb, and from which more nerves come out than enter in ‡.

Seventhly, We shall more readily receive the opinion that the ganglia are additional sources of nervous energy, if we are persuaded, from what has been before observed, that every nerve is, in its course, covered with cineritious matter, from which energy is added to it.

Eighthly, When we compare a lymphatic conglobate gland with a ganglion, we remark a striking resemblance. The lymphatic vessels form a net-work on the surface of these glands, in which we can readily trace their whole course. Other lymphatics enter into the substance of the gland, which, in its number of blood-vessels, its colour, and consistence, very much

* Mem. de l'Acad. des Sc. a Berlin, 1749, p. 91. Zinn and Haller adopt the opinion of Dr Meckel, that the ganglia are not sources of nervous matter and energy, Mem. de l'Acad. a Berlin, 1753. and Hal. El. Phys. Tom. 4. p. 408.

† See Santorin, p. 62. Weitbrecht, Winslow, T. 4. § 133. Soemmering, de Basi Enc. p. 89. et Tab. 1. and 3.

‡ See Tab. XXXII. Fig. 1. K.

much resembles a ganglion: Thus, till we trace the splanchnic nerves into the semilunar ganglia, we are apt to mistake them for conglobate glands. Yet no person who understands the subject can doubt, that, in the conglobate glands, the arteries make a secretion of matter, which is added to the lymph, although the nature of that matter has not yet been fully ascertained by experiment.

S E C T. VII.

UPON the whole, all the nerves which issue from ganglia seem to be formed by a combination of threads from many sources; and, beside this, the nerves, in their passage through a ganglion, seem to receive new energy from the vascular matter of the ganglion.

Hence we understand the reason why ganglia are most numerous in the nerves of organs of chief importance, as in those of the heart or of the intestinal tube. Thus, the intestinal tube receives its nerves from the eighth pair, and, perhaps, from almost all the spinal nerves. If the first pair of spinal nerves had run to the uppermost part of that canal, and so on, without the intervention of ganglia, by a wound or disease injuring the first pair of nerves, the uppermost part of that canal should have totally lost the power of acting: Whereas, if the threads are supposed to be intermixed in the ganglia, we should, by such an accident, make a loss of the thirtieth part only of the power of the whole tract; which equable loss would be attended with much less danger than the complete loss of power in the thirtieth part of it.

Or in the heart, the loss of one fourth part of the strength of all its four principal facs would be less dangerous than a complete palsy of one of its auricles or ventricles*.

P

Whilst

* The three purposes the ganglia are said, by Dr Meckel, to serve, Mem. de l'Acad. des Sc. a Berlin, 1749. p. 96. To wit,

1. De diviser un petit nerf en plusieurs nerfs :

2. De

Whilst I mention the above as the primary purposes which the structure of the ganglia points out, I think it highly probable there may be other yet latent purposes served by them.

S E C T. VIII.

As the heart and bowels of the abdomen are remarkable for the various sources of their nerves, and for the number of ganglia through which these are transmitted, and also for their extensive sympathy with other organs, we seem to receive a confirmation of what I alledged above in CHAP. XVII. that the extent of the sympathy of our organs is in proportion to the number of connections their nerves have with different parts of the brain.

C H A P.

2. De faire parvenir les nerfs commodement par des directions differentes aux parties :

3. De reunir plusieurs petites fibres nerveuses en un gros nerf : Might have been nearly as well executed without ganglia as with them ; and that they are magazines for furnishing cellular membranes and coats to the nerves, as he contends, seems a frivolous hypothesis, not connected with any appearance in their texture.

That ganglia do not serve to render motions independent of our will, as an ingenious author has supposed, is evident, without observing more than that all the branches of the fifth pair, and the posterior half of all the spinal nerves of the voluntary muscles, pass through ganglia.

C H A P T E R XX.

Of Spheroidal Bodies which, in some Animals, make Part of the Nervous System.

IN fishes of the genus *gadus* of Linnaeus, to wit, in the cod, the whiting, and the haddock, I have discovered a great number of spheroidal bodies, between the dura and pia mater, on the outside of the brain, cerebellum, and top of the spinal marrow, lodged in a viscid clear humour, which is interposed between the cranium and brain*. Other such bodies are found between the membranes of the semicircular canals of their ear, and the canals of bone which contain them, dispersed in a viscid humour which is interposed between these osseous and membranous canals.

When we carefully observe the situation of these spheroidal bodies, they seem to be supported, in their places, not merely by the viscosity of that humour, but to have blood-vessels, and likewise white fibres, partly cellular, and perhaps, in the ear, partly nervous, connected to them.

A pair of very large nerves, which seems analogous to our fifth pair†, and all the nerves from the spinal marrow, are covered with these spheroidal bodies as with a coat of mail, from their origin to their division into branches‡, when the spheroidal bodies become fewer in number, so that the nervous cords are seen in their interstices. The minute branches or terminations of the nerves are not attended by these bodies, but are quite similar to the nerves in other fishes or in other classes of animals||.

These

* See Tab. XXXII. Fig. 1. D. E. F.

† See Tab. XXXII. Fig. 1. M. M.

‡ See Tab. XXXII. Fig. 1. and 2. Tab. XXXIII. Fig. 1. Tab. XXXIV.

|| See Tab. XXXIII. Fig. 1. B. C. Tab. XXXIV. Fig. 1.

These spheroidal bodies adhere firmly to each other, and to the outer part of the nerve.

The spheroidal bodies consist of a tough outer transparent membrane, or skin, which contains a viscid transparent humour, in the heart of which there is always one white or opaque body, but, generally, we shall find two such bodies, bent in a figmoid way*. We may compare these spheroidal bodies to an egg, with its shell peeled off; only we must imagine the serpentine bodies to be substituted in place of the yolk.

After drying the spheroidal bodies, the serpentine white bodies are still very distinguishable. They are so like in colour and consistence to the cretaceous substance in the ear of a skate, that I have some suspicion they are cretaceous; but I neglected to try a proper experiment to determine this point.

None of these spheroidal bodies are connected to the olfactory or optic nerves†, nor to the trunk of the portio mollis; but some threads from the portio mollis seem to be joined to them, between the membranes of the semicircular canals of the ear and the cases of bone which contain them.

They are also wanting in the course of a pair of nerves from the brain, which runs down the sides of these fishes‡.

These bodies, no doubt, serve some office of high importance; and, perhaps, an accurate comparison of this with other kinds of fishes, and with other animals, may serve to throw light on the nature of the nervous energy.

At

* See Tab. XXXII. Fig. 3. Tab. XXXIII. Fig. 2. 3.

† See Tab. XXXII. Fig. 1.

‡ See Tab. XXXII. Fig. 1. S.

At first, I supposed these bodies might supply the place of ganglia, which I found wanting at the roots of their spinal nerves. But, in other fishes, there seems to be a similar defect of such ganglia.

Q

C H A P.

CHAPTER XXI.

Of some principal Nerves which have not been properly Traced by Authors.

IN this chapter I shall describe some principal nerves which have not been properly traced by authors.

1. I begin with observing, that the branches of the first, or olfactory pair of nerves, are not so extremely soft, and so suddenly diffused upon the membrane of the nose, that it is impossible to trace them distinctly by dissection, as Dr Zinn and Dr Haller have affirmed*; on the contrary, they may, even in the human subject, be traced a great way within the nose, where their small branches are joined, and again separated, so as to form a very elegant net-work†.

In the sheep and ox these nerves are hollow, and a branch is sent off, not, like the rest, from the bulb at the end of the trunk, but from the upper part of the trunk, within the cranium, and hence it can be traced more easily than the other branches‡.

Whether,

* Zinn Mem. de l'Acad. de Berlin 1755, tom. xi. p. 132. Quiconque en a fait l'experience, reconnoitra avec moi, que la moleste coulante et muqueuse du nerf Olfatoire, depuis qu'il a passé la lame aethmoide, empeche entierement qu'on puisse affirmer quelque chose de certain de sa distribution, ou de son Anastamose avec les autres nerfs.—Haller, El. Phys. tom. iv. p. 200. Ita olfactorius nervus, nusquam equidem durus, in pituitaria membrana mollissimus expanditur, ut ramos in homine persequi nequeas.

† See Tab. XXIV. Fig. 1. and 2.

‡ See Tab. XXIV. Fig. 5. H.

Whether, in man, these nerves are hollow, and whether a similar nerve is sent off from them, I have not had leisure to examine sufficiently.

2. The nasal branch of the first branch of the fifth pair carries along with it a firm white external coat, and hence may, with still greater ease, be traced in man, as well as in the sheep or ox, to the upper, or fore part of the septum narium *.

3. The nasal branch of the second branch of the fifth pair can likewise be very easily traced within the nose †; and in the ox and sheep, it is evidently spent on the lower part of the septum narium, as well as upon the ossa spongiosa and side of the nose ‡.

4. The extent of the retina has been very differently described by anatomists. Morgagni, my Father ||, and Zinn §, have affirmed that it terminates at the ciliary circle; whilst authors of equal authority, Eustachius, Winslow, Ferrein, and Haller **, have represented the whole or a part of it as extended to the lens, and even as giving a covering to that humour.

The opacity, however, of the retina, compared with the pellucidity of the capsule of the lens, and the confusion, which we must suppose, would arise from light striking the retina before its rays are collected into a focus, render this latter description very questionable; and, in fact, not long after I began to study anatomy, led by these contradictory accounts, to examine this subject with particular attention, I found that the retina ended abruptly, resembling the edge of a tea-cup, somewhat farther back in the
eye

* See Tab. XXIV. Fig. 3. 4.

† See Tab. XXIV. Fig. 3.

‡ See Tab. XXIV. Fig. 5. I. K. L. M. N. Fig. 6. K. P.

|| Anat. of the Nerves, 1741, p. 41.

§ Zinn, de Oculo, 1755.

** Haller, Pr. Lin. Phys. 1764, p. 515.

eye than the ciliary circle, or, that it covered that part only of the bottom of the eye on which the pictures of objects can be distinctly painted,

To demonstrate more clearly the extent of the retina, in some of my first courses of anatomy, I used to pour a few drops of rectified spirit of wine on it, which instantly renders it much more opaque than natural, and thereby makes its termination much more distinctly visible; but I observed, that, in a short time thereafter, a somewhat similar opacity is communicated to such part of the lens as the spirit touches, and, to an inattentive observer, suggests the idea, that the retina is continued to cover it; or, if we do not dissect the eye till some time after it has been immersed in ardent spirits, the capsule of the lens and retina appear so nearly of the same colour, that we are apt to suppose the one to be the continuation of the other.

I am therefore persuaded that Dr Haller has been misled, (particularly in the dissection of the eyes, represented in his *Fasciculus Anat.* VII. Tab. VI. fig. 7. & 8. which seem to have been injected and preserved in spirits), by not having sufficiently attended to the effects which ardent spirits have of coagulating the lens, and giving it an opacity like to that of the retina.

5. In 1753, when I received Dr Meckel's elaborate treatise on the 5th pair, I observed, that, by an unaccountable error, the trunk of the internal carotid artery is represented by him as passing between the second and third branches of that nerve; whereas it is on the inner side of both; and hence that his new-discovered reflected branches of the fifth pair are represented quite out of their real place. I demonstrated this error by a preparation I made at that time; a figure of which the reader will find in Tab. XXVII. *.

6. Although,

* See Tab. XXVII.

6. Although, from the great sensibility of the teeth, it is evident they are provided with nerves; yet one of the latest writers on that subject has alledged, that these cannot be prosecuted by dissection *. But I have, twenty years ago, observed, and demonstrated, first, That the proper inferior maxillary nerve is sensibly smaller where it goes out of the hole at the chin, than where it enters the canal at the inner side of the jaw-bone: In the next place, That the nerves of the teeth can not only be distinctly traced from their trunks, but that, in a child at birth, their several branches can be plainly shown, first connected so as to form a plexus, and after that entering the pulp of the tooth. Other branches pass between the teeth to the gums †.

7. Several celebrated authors ‡ have affirmed, that, if the recurrent nerves are cut, the voice is entirely lost. But as the larynx receives a pair of superior laryngeal, as well as recurrent nerves, my father, long ago, ventured to express a suspicion, that such experiments had not been made with sufficient accuracy ||. In 1752, I found proof that this was really the case; for, at that time, assisted by the ingenious Dr Emmett, now State Physician in Dublin, I cut those nerves in a small dog, and observed, that, although the voice of the animal was very sensibly altered in tone, and weakened, yet it was far from being lost; nay, in the course of six weeks, the strength of the voice was in a considerable degree restored. Hence there was reason to conclude, that each of the muscles received branches from the superior laryngeal nerves. Since that time I have found, on dissecting the nerves of the human larynx, that the recurrent and superior laryngeal nerves are joined together by their apices, or that they form a

R

plexus,

* Mr J. Hunter, on Teeth, p. 42. says, 'By injections we can trace the blood-vessels distinctly through the whole cavity of the tooth; but I could never trace the nerves distinctly even to the beginning of the cavity.'

† See Tab. XXV.

‡ Galen, Vesalius, Bidloo, La Motte, Riolan, Chirac, Valsalva, Morgagni, Martin.

|| See his Treatise on the Nerves, 1741.

plexus, resembling that of the nerves of the face; and that, from both nerves, each muscle of the larynx receives branches *.

8. Dr Haller has denied that any nerve can be traced into the ligament of a joint; but I have observed, that the back-part of the ligament of the carpus has constantly fixed to it a small branch from the muscular spiral nerve of the arm. This branch has not altogether escaped the notice of Dr Haller, but he alledges that it is continued to supply the interossei muscles †. On, however, examining this branch accurately, although some filaments from it run farther than the wrist, to the membranes on the back of the hand, yet the greater part of it seems to end there in the ligament ‡; and the interossei muscles are supplied from the ulnar nerve, after it reaches the palm of the hand.

9. The chorda tympani seems to be formed by the second branch of the fifth pair, as well as by the portio dura of the seventh, as it comes off after these two nerves are conjoined; and it is evidently added to the lingual branch of the third branch of the fifth pair, as it increases its size ||.

10. In several tables I have represented, with accuracy, the progress and termination of the portio mollis of the seventh pair in the cochlea of the human ear, which I first traced in an adult subject, in the end of the year 1756, and of which no account has yet been given by authors §.

C H A P-

* See Tab. XXV.

† Haller, El. Phys. tom. 4. p. 247.

‡ See Tab. XXVI.

|| See Tab. XXVIII.

§ See Tab. XXIX. Tab. XXX. Tab. XXXI.

C H A P T E R XXII.

Of the Appearance of the Nerves viewed with the Microscope.

S E C T. I.

AFTER examining the structure of the nervous system with the naked eye, or with a common magnifying glass, I attempted to trace the nerves, by the assistance of the microscope, to their termination.

I preferred the compound microscope, as it takes in a larger field than the single lens, and, therefore, suits a painter better; and as, from the reason of things, as well as from the account of authors, it is certain that the nerves are ultimately divided into very minute parts, I generally employed a microscope, which I found, by calculation, increased the diameter of objects 146 times, or their surface 21,316 times, and illuminated the object by the light of the sun reflected from a plain or concave mirror.

As I had traced the portio mollis of the auditory nerve to its termination on the very thin membrane of the cochlea, and had found I could distinctly observe its subdivisions a very great way, with a common magnifying glass, or with a microscope of inferior powers, I began with examining it in the preparation delineated in Table XXXV.

I was much surprised to observe, that its ultimate fibres appeared to be serpentine and convoluted, very much resembling the winding of the seminal ducts in the testicle or epididymis.

I compared with it the termination of the optic nerve in the retina, and observed an exact resemblance. When I made a calculation, I found that
the

the real diameter of an object of the apparent size of those convoluted fibres, would be nearly equal to the $\frac{1}{1000}$ th part of an inch.

The fibres in some parts of the medullary substance of the brain, and in the trunks of the nerves in general, seemed, to the naked eye, so evidently straight, that I supposed the structure I had seen might be proper to these organs of sense. But, when I came to apply my microscope to the medullary substance of the brain, to the fibres in the trunks of the nerves, and at last to the muscles, nay to the bones, the teguments, and even the hairs of the body, I was astonished to find in all a similar appearance.

I showed what I had observed to some friends, distinguished by their genius and learning, and who were practised in microscopical observations.

They saw distinctly, and were surprised with the appearances I have been describing.

In January 14th 1779, I read to the philosophical society of this place, an account of the appearances I had observed; but not having finished the experiments I proposed, and not being satisfied upon the subject, I declined lodging my paper with a member of the society for a report, which is the common practice.

Soon after I observed a similar appearance, not only in the recent parts of vegetables, but in the fossil kingdom, and in all solid bodies, whether opaque or pellucid.

Of these observations Dr Duncan, without my desire, wrote some account, under the article of Medical News, Vol. vi. Part 1. of Medical Commentaries. The Doctor was, however, so obliging as to show me what he had written before it was sent to the press.

At

At first, and especially whilst my observations were confined to the nerves, I had little or no suspicion that the appearance I remarked could be an optical deception; for the fibres I saw appeared to be bent and convoluted in a very beautiful, distinct, and uniform manner.

They seemed larger or smaller, in exact proportion to the known magnifying powers of the microscopes I employed.

When I applied to the microscope the leg of a small transparent animal, such as a spider, I saw, at the same instant, and with equal distinctness, the convoluted fibres and the round particles of the blood circulating in the vessels.

When I examined melted wax, spermaceti, or tallow, I saw no such appearance; but, at the very instant of their becoming somewhat opaque by cooling, I saw the mass shoot into such fibres: Or, when I evaporated water, in which salt was dissolved, as soon as the crystals began to shoot, I saw serpentine fibres beginning to form in them.]

All the metals melted, and allowed to cool, seemed to be composed of such fibres; so that it could not be said that this appearance was produced by scratches made accidentally, or by attrition.

No author had remarked as a fact, that an appearance so distinct and uniform, could be produced by an optical deception: And

I could not find principles on which the production of so great a deception could be sufficiently explained.

After, however, I had extended my observations not only to the vegetable, but to the mineral kingdom, and more carefully sifted, and more

coolly considered every circumstance, I began to suspect some optical deception, though I could not sufficiently explain the causes of it.

In short, to give the reader an idea of the distinctness of the appearance, or its seeming reality, and, at the same time, to give him a convincing proof of the difficulty of finding optical principles by which the causes of so great a deception can be explained, I need only to mention, that, after I had extended my observations to the vegetable and mineral kingdoms, and had had time to consider every circumstance, and, particularly, had remarked that the convolutions seemed to change place, by altering the direction of the light, in a greater degree than could be accounted for from the mere alteration of the shades, if the fibres were real and fixed in their place, and that I had written, on April 1st 1779, the grounds of my doubts to one of the first speculative as well as practical opticians in Europe, he answered my letter in the following words:

‘ I have examined the different kinds of substances mentioned in your
 ‘ letter to be composed of serpentine fibres, and see it clearly in human hair,
 ‘ but as to the rest, am in some doubt; but, perhaps, I have not tried it
 ‘ sufficiently, my time being very much taken up in business. I cannot
 ‘ think that the appearance of these fibres can be any optical deception,
 ‘ but their shifting may be so, though it is not the fibres only which seem
 ‘ to move, but the whole object, and I think it may be owing to the dif-
 ‘ ferent refrangibility of light; for the more the aperture of the object lens
 ‘ be opened, the more this will appear. The small circles of aberration
 ‘ occasioned by the refrangibility, appear different, as the light is thrown
 ‘ in different directions, and the eye may be more affected by some colours
 ‘ in one case, and by others in another.

‘ I have the honour to be,

‘ Sir, your obedient servant.’

When,

When, however, all circumstances are duly weighed, we must, I apprehend, be led to conclude, that this very curious form, in which bodies viewed by the microscope appear, is produced by an optical deception; for, independent of the improbability that the particles of all kinds of matter shoot into similar and visible forms, I found, on accurate inspection,

1. That, in viewing hairs, and other objects, the serpentine turns seemed more numerous, as well as more distinct, when the light did not fall perpendicularly upon the object, but in a slanting direction.

2. In the next place, although I observed, that, when I placed a small bunch of serpentine woollen threads before the microscope, and threw the light upon them in different directions, the fibres beyond the focus seemed to change place, yet the number and direction of the turns at the focus remained the same; whereas, in the appearance of serpentine fibres I have been describing, the number, situation, and direction of turns was greatly altered by altering the quantity and direction of the light.

I thought, at first, after I observed the shifting of place in the serpentine turns, that this might be accounted for from the difficulty, or impossibility, especially where a microscope of high magnifying powers is employed, of bringing all the fibres to the exact focus, and that this apparent shifting might be similar to the shifting I had observed in the bunch of woollen threads. But I afterwards found that the apparent shifting is greater than could be accounted for in that way; and my very ingenious colleague Mr John Robison, Professor of Natural Philosophy, who was so obliging as, at my desire, to examine this subject, is of opinion, that the appearance of these convoluted fibres is an optical deception, arising partly from the unavoidable aberration of light in the microscope, and partly from the irregular dispersion of it from bodies, whose inequalities are neither incomparably greater nor incomparably smaller than the distance at which light is acted on by bodies.

I found that tallow, or any other soft substance, had the same appearance, after being spread, with a knife, upon a plate of glass, as when, after being melted, it was allowed to cool upon the glass. Yet although, after being melted and cooled upon the glass, it had shot into serpentine fibres, in the same manner as salts shoot into crystals, the figures of these should have been destroyed, or altered, by the mechanical pressure of the knife.

4. In like manner, when I tried a similar experiment, suggested by my learned and judicious friend Dr Rutherford, of comparing gold, beaten into exceedingly thin leaves, with gold melted and cooled again, I found no difference in their appearance; whereas, if the gold really consisted of serpentine fibres, these, by the beating, should have become broader, and, of course, should have appeared larger, and less numerous in the same space.

As these appearances produced by the microscope are so extremely regular and distinct, as to be very apt to mislead; as they have escaped the observation of authors; and, as the consideration of the causes of them may tend to throw some light on the science of optics, I thought it might be acceptable to the reader to see delineations of them. I have, therefore, added tables representing different objects, viewed with the microscope*.

S E C T. II.

IN material anatomical points, I suspect that this deception, produced by the microscope, has misled some authors, particularly the late Mr Hewson and Mr Falconer. In Mr Falconer's *Experimental Inquiries*, Plate iv. fig. 4. cells are delineated, such as are said to be observed in the lymphatic glands, which cells will, I apprehend, be found to exist in the microscope only, this figure being merely an imperfect representation of the deception produced by that instrument.

The

* See Tab. XXXV. to Tab. XLV. inclusive.

' The size and shape of cells in the spleen,' we are told by Mr Falconer;
' so nearly resemble those we have before described in the lymphatic glands;
' that a tolerably accurate idea of them may be obtained by referring to
' the above mentioned plate *.'

I would here repeat my observation made on the supposed cells of the lymphatic glands, adding to it, as a decisive proof that a mistake was committed by these authors, either in fact, or in theory, about the spleen, that the diameter of these cells represented, is not larger than the sixtieth part of an inch, when viewed through a lens of $\frac{1}{30}$ th of an inch focus, so that their real diameter should not exceed the 24,000th part of an inch, yet the red particles, the diameter of one of which is said, by Mr Hewson, to be almost equal to the $\frac{1}{1000}$ th part of an inch, are by them supposed to be contained and completed within these cells.

Nay, in Plate iv. fig. 2. the vesicles of the red particles of the blood, viewed through a lens of $\frac{1}{17}$ d of an inch focus, are delineated nearly double the diameter of the cells of the spleen, though viewed by a lens $\frac{1}{30}$ th of an inch focus, represented in Fig. 4.; so that one vesicle of the blood is represented by Mr Falconer himself above sixty times the size of one of the cells of the spleen, within which, he teaches, it was contained and formed.

T

C H A P.

* Falconer, Exper. Inq. Sect. 65. p. 108.

CHAPTER XXIII.

Of the Nature of the Energy of the Nerves.

AFTER examining the structure of the nerves, we are led to consider the nature of the nervous energy.

Most authors have supposed that the nerves are tubes or ducts conveying a fluid secreted in the brain, cerebellum, and spinal marrow. But, of late years, several ingenious physiologists have contended, that a secreted fluid was too inert for serving the offices performed by the nerves, and, therefore, supposed that they conducted a fluid the same as, or similar to, the electrical fluid.

Two arguments chiefly seem to have led them to this conclusion.

First, The nervous energy appeared to them to be moved with prodigious velocity. Thus, Dr Haller observes how often a muscle of any part could act in a minute; and supposing that, previous to every contraction, the nervous fluid moved from the brain to that part, has attempted to calculate its velocity*.

But if the nerves are constantly filled or charged with their fluid or energy, which, from our instantly perceiving injury done to every the most remote part, we have reason to suppose is the case, an impulse given to that fluid at the brain may be suddenly communicated to the most distant organ, although the velocity of the fluid be very small. Nay, in fact, we find,

* Haller, El. Phys. L. x. and xi. * L. x. p. 373. Ita invenio, summam tamen celeritatem esse muscularis liquidi, ut non minus quam 9000 pedes in minuto primo percurrat.

find, after cutting through the nerve of a muscle, that, by irritating the nerve, repeated motions can be performed; whereas, by Dr Haller's theory of great velocity from end to end of the nerve, as the nerve now wants supply from the reservoir in the brain, the fluid should be exhausted by a single effort of the muscle. Such an argument as this no more proves that the nervous fluid moves with great velocity, than our letting out, in the space of a minute, a hundred successive drops of water from the end of a pipe, a mile distant from the reservoir which filled it, would prove that the water was moving in that pipe at the rate of a hundred miles every minute.

The other principal argument is more direct, and has been thought very conclusive, to wit, that some animals, as the torpedo and gymnotus electricus, have the power of giving an electrical shock, and that, on dissecting them, a piece of machinery, proper to them, is discovered, in which large and numerous nerves terminate.

But, perhaps, all we can conclude from these facts is, that the nerves enable this machinery to perform its proper office of collecting the electrical fluid, but without directly furnishing to it any of that fluid. Just as we, by rubbing a glass tube, excite electricity without there being any reason to suspect that the electrical matter is, in particular, derived from the nerves of our hand, since the electricity could be as readily excited by the hand of a dead man, as by that of a living, rubbed against the glass with the same force.

We seem, therefore, far from possessing positive arguments that the nerves operate by the medium of an electrical fluid, especially if we add, that, after cutting a nerve across, and again bringing its parts contiguous, its offices cannot be immediately restored. Nay, I have found in frogs, that, although the divided parts grow together again, the influence of the nerve beyond the incision is generally not recovered. On the other hand,
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the well known effects of compression on the nerves of a sound animal, and the experiment of producing repeated contractions of a muscle by pressing its nerve, after cutting it across, seem to indicate that the energy depends on matter capable of being affected by simple pressure.

That the matter on which the energy depends is a secreted fluid, we are, indeed, far from being able to prove.

But, to say that the offices of the nerves are not performed by a secreted fluid, merely because we cannot comprehend how any part of the blood, or any humour prepared from it, could render the mind sensible of an injury, or throw a muscle into action, is, in my opinion, saying a great deal too much; for, in the generation of animals, effects more incomprehensible and astonishing seem to depend on the secretion and mixture of the fluids of the testes and ovaria; the brain, the nerves, the nervous energy, and complex fabric of other organs, being thereby produced.

C H A P T E R XXIV.

Of the Uses of the Nerves.

THAT, by the medium of the nerves, we feel, and are enabled to perform motion, is very generally agreed; but many eminent authors have, at different periods, supposed that the nerves also contain or conduct the matter by which the body grows or is nourished*.

This notion I shall in the first place consider.

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C H A P.

* Glisson, Charleton, Ent, Cole, Vieussens, Willis, Boerhaave, Santorinus, Mazinus, Kinneir, &c.

CHAPTER XXV.

Whether the Nerves convey the Nourishment to our Organs.

THREE chief arguments have been employed by those who of late have maintained that the nourishment is conveyed by the nerves.

1. They pretend that the brain exists before the heart.
2. That the limbs shrink in the palsy, because the nerves are so diseased as to be incapable of conveying the nourishing fluid.
3. They suppose that a secreted fluid is not sufficiently subtile and moveable for the purposes of sense and motion, and, therefore, conclude that the fluid which they admit the brain secretes, must serve the only remaining purpose of nutrition.

S E C T. I.

BUT, on the first of these propositions, that the brain exists before the heart, I would observe,

1. That it is contradicted by Dr Haller, who, after the most accurate observations which have been made on that subject, concludes, that there is merely an evolution of the parts of the foetus, without the addition of any new part*.

In

* Haller, Op. Minor, Tom. II. c. xv. p. 407. says, 'Didici ea ipsa exempla quae credebam refutare evolutionem, confirmare quam maxime. . . . Nihilque quidquam novi nasci.'

In the egg, at the end of 38 hours from the beginning of incubation, he could perceive the heart projecting from the breast; and, at the end of 45 hours, he could distinguish its auricle, ventricle, and aorta, their motion, and the blood beginning to grow red: And he observes, that its parts and their motion were not sooner distinguishable from their smallness and pellucidity only*. To confirm which, we may observe, that the lungs and other organs, when first observed, were of such size that they might easily have been seen long before, if they had not been pellucid†. But the head was not distinguishable till the 41st hour, the eyes not till the 51st, at the 120th hour the brain was watery, and, so late as the 168th hour, looked like mucus; and, at the 131st hour, spontaneous motion of the foetus was first observed‡.

2. Nay, independent of the actual observation of Dr Haller, does not the error of supposing the heart and vessels to be wanting whilst the animal is growing, appear manifest, if we ask ourselves the following plain questions; How has the brain itself, from being so small as to be invisible, grown so large as to be visible? By what channels did it receive its own nourishment? Or, by what means did the liquor, supposed to have been conveyed by the nerves to other organs for their nourishment and growth, make its way into those nerves? Are we to suppose the brain and organs
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* Haller, Op. Min. Tom. II. c. ix. p. 369. 410. Cordis in universum primum vestigium vidi hora 38 rotundum aliquid de pectore eminens. Dein hora 42 et cor vidi et aortam et motum sanguinis rubiginosi ex corde. Hora 45 tres vesiculas vidi et earum micationem, ut prima auricula subfiliret, inde ventriculus, demum aortae bulbus. Si cordis motus non prius oculis usurpari potest, causa est in parvitate et pellucida natura ejus particulae. Non certe ideo nullus in eo organo ante eum diem motus fuit, cum ab ejus unica vi celerrimum incrementum primi diei pendeat.

† C. x. Pulmones. 'Primum mihi adparuerunt 120 hora . . . non ita parvi, quin etiam prius potuissent conspici, nisi pellucidi fuissent.'

‡ Haller, Op. Min. Ovum 48. Horarum 41. Caput distinguo, p. 412. 'Evolvuntur oculi hora 51. —p. 361. 'Hora 120. Cerebrum aquosum.—p. 361. 'Hora 131. Foetus primum motu spontaneo se concussit.—p. 362. 'Hora 168. Cerebrum mucosum fuit.

of the foetus to be nourished in one way before it gets its heart and vessels, but in a different way after it gets them?

In short, as all the veins, whether lymphatic or red, convey their liquors directly to the heart, and, by the intervention only of the heart, to the brain, the existence of the heart must precede the growth of the brain. I do not say, on the other hand, that the heart is formed before the brain; because, as these two organs act upon each other in a circle, it appears to me manifest that they must be coeval.

S E C T. II.

ON the next argument, that palsied limbs shrink, as if the sources of nourishment were intercepted, I would observe, that this shrinking is to be expected, on the supposition that the arteries convey the nourishment; for, *first*, Nuck found that the inferior maxillary gland did not properly secrete the saliva when its nerves were cut*. Surely we are not, therefore, to conclude that the saliva is derived from the nerves. The proper conclusion is, that the organs of secretion are not mere sieves, but possess feeling and activity, without which they are incapable of performing their proper offices. When, therefore, the nerves of a limb are palsied, it shrinks, because the arteries are deprived of that degree of nervous energy which enables them to act properly in secreting and applying the nourishment.

And to support this way of reasoning, it may be remarked, that where, in consequence of pain, luxation, fracture, laceration of a tendon, or other accident, a limb is confined long to one posture, it shrinks; and that, on the other hand, exercising any limb much increases its bulk as well as strength, showing the effect of activity in nutrition.

Next,

* Nuck Sialographia 1690, p. 24. ' Si ligatura injiciatur in nervum ad glandulam tendentem, aut transversim dissecetur nervus, non tamen ideo secretionem cessare observabimus, sed tardiore solummodo et magis lentam procedere.

Next, I would alledge that the degree of the shrinking of the limbs in paralytic cases has been much exaggerated by some physiologists. For, although, in a few cases, where the whole frame is unhinged, I have, indeed, seen it very considerable, yet, in general, though the feeling and motion be greatly impaired, the loss of substance is not, after the disease has continued for years, very distinguishable.

Nay, a year after I had cut, in a living frog, the trunk of one of the sciatic nerves, I could not observe that the limb, on which the experiment had been made, was smaller than the other, though it continued to be without sense or motion.

S E C T. III.

With respect to the third argument, that a secreted fluid is not sufficiently subtile and moveable for the purposes of sense and motion, and, therefore, that the fluid conveyed from the brain by the nerves, as its ducts, must serve for nutrition, I have already remarked, that experiments do not certainly prove that the nervous energy is very subtile and moveable. But next, supposing such proof to be given, or that sense and motion are not performed by a secreted fluid, I would ask by what arguments we could, in that case, prove the brain to be a gland, and the nerve its ducts? As things now stand, although we know that we can intercept the influence of a nerve by a ligature, or by pressure upon it; that, when the pressure is suddenly removed, there is a thrilling and degree of pain, as if some matter had been accumulated, which now rushed down into the limb; and that, by pressing a nerve after it is cut across, we throw the muscles into action, the proof that a nervous fluid exists is far from being satisfactory. How much, then, will that proof be weakened, when we deny that sense and motion depend on a secreted fluid, and when, of course, we set aside that evidence of a nervous fluid, which the above experiments seem to furnish?

S E C T. IV.

BUT, on this question, we can, I apprehend, not only detect the fallacy of those arguments which have been used to show that the nourishment is conveyed by the nerves, but point out a variety of circumstances which are inconsistent with such an hypothesis; and, on the other hand, we can, by decisive experiments and arguments, prove, that the arteries directly secrete and apply the nourishment, without the intervention of the nerves.

Without insisting farther on our uncertainty of the nature of the nervous fluid, and, indeed, of its very existence, the following circumstances are inconsistent with the idea that a fluid conveyed by the nerves nourishes.

1. On comparing different animals we are far from finding any correspondence between the size of their brain and rapidity of their growth, or quantity of nourishment they receive.

Thus, though an ox be six times heavier than a man, his brain does not weigh above a fourth part of that of a man. Does his brain, then, prepare twenty-four times more nourishment than a portion equal to it of the brain of a man?

Nay, in the space of two years, an ox comes to his full size, so that his brain must be supposed to transmit through the nerves daily two or three pounds of flesh, bones, &c. whilst the much larger brain of the man has not, in the same time, added to his weight above a fiftieth part of the increase of the weight of the ox. Or, the brain of the ox, beside repairing the waste of a much larger body, is, by such an hypothesis, adding to his weight, in any given period, two hundred times as much as an equal portion of the brain of the man adds to his bulk.

Suppose,

Suppose, then, both animals to be fed on milk, we must believe that the milk passes two hundred times quicker through every medullary fibre of the brain of the ox than through the medullary fibre of the brain of the man.

2. In monsters, I have found the limbs very plump, though the brain was very small*. Nay, in some monsters, the head has been wanting, yet the limbs were as large and perfect as common. In other monsters with one head and two bodies, I have found that the brain furnished the nerves of the head and spinal marrow on the right side of the monster; yet the left spinal marrow, at the top of which there was only a small medullary knob, about the size of a large pea, was as perfect as the right one, and that body and its limbs were as large and well nourished as those on the right side†. On the other hand, where there were two heads of the ordinary size, and only one body, the limbs were not remarkable for their size‡.

3. We see that organs, of which the nerves are so small that we cannot trace them by dissection, as the bones, the placenta, &c. grow as quickly as the other organs in which the nerves are large and numerous.

4. A year after I had cut across the sciatic nerve of a living frog, I could not perceive that limb smaller than the other, yet it continued to be insensible and motionless. Nay, when I had broken the bones of the insensible limb, or wounded the skin and flesh, I found that the callus formed, and the wounds healed as readily as if the nerve had been entire. The event was the same, after dividing, transversely, the lower or posterior end of the spinal marrow of the frog.

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* Tab. VIII.

† Tab. XII. Fig. 3. 4.

‡ Tab. VIII. **

5. Can we imagine that our organs, varying so greatly in colour and consistence, are nourished by the nerves which seem uniform in their appearance?

6. To conclude with an argument against this hypothesis which may be considered as an *argumentum crucis*, it is well known, that, if powder of madder root is mixed with the food of a young animal, the bones become red; or, if a bone has been broken, that the callus joining its parts will be red. The serum of the blood, in the first place, is deeply tinged; but the red colour of the bones is not solely, nor even chiefly, owing to the coloured serum or blood circulating; for I have found, that, after injecting water into the vessels till these were emptied of the blood, and that the water came out colourless, the tinge in the bones appeared equally deep, and was, therefore, plainly owing to a great quantity of the red earth added to the bones in the time of their growth. But this earth was not transmitted by the nerves; for the colour of these, as I found, remained unchanged.

S E C T. V.

WHEN, on the other hand, we direct our attention to the offices of the arteries, a variety of circumstances crowd upon us, which concur in showing, that, from their extremities, the nourishment is directly supplied.

1. The thoracic duct conveys the chyle into the red veins, which terminate in the right side of the heart, so that the chyle comes to be intimately incorporated with the whole mass of blood in its passage through the lungs, instead of taking a particular direction towards the brain.

2. The chyle, in the general course of circulation, is converted into blood, the glutinous matter of which, called coagulable lymph, much resembles the glaire of an egg, and seems equally fit for the growth or reparation of the parts of an animal. Nay, some late writers, who contend that nourishment

ment is conveyed by the nerves, suppose that they perform their office by separating this gluten from the blood. So that the chief or only remaining question seems to be, Whether the extremities of the arteries or the nerves are to be supposed to perform the secretion of it, and nutrition of course? Now, without repeating our extreme uncertainty as to the tubular nature of the nerves, and the improbability that canals so exceedingly minute as those within the nerves must be, and of such length, are destined for the conveyance of glue, do we not find that this very matter is separated by the exhalant branches of the arteries of the peritoneum, pleurae, and other shut sacs, and universally, by the branches of the arteries of the cellular membrane?

In like manner, is not the glaire of an egg, the nourishment intended for the chick, secreted and prepared by the arteries of the Hen?

3. The kinds of matter necessary for the growth and nourishment of our several organs are so various and different in their nature, that it is altogether incredible they can be furnished by the nerves. Thus, water is needed for the extension of the fore part of the eye, viscid matter for the crystalline and vitreous humours, earth for the growth of the bones, &c. Whereas we can as easily conceive these to be furnished by the arteries, as that, in one place, they should furnish saliva, in another the bile, in a third the semen, and so on.

4. In several instances, an increase of secretion from the arteries produces effects which we very universally ascribe to an increase of nutrition. Thus, the weight of the humours of the eye increases after birth: Or when a person, reduced by a tedious fever, has grown plump again, we conceive that a quantity of fat has been secreted into the adipose follicles. Nutrition and secretion by the arteries are, in such instances, synonymous terms.

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5. As the waste of the several organs is carried off by the vessels, either circulating or absorbent, for we have not yet heard of absorbent nerves, though, indeed, hypotheses not less extravagant have, of late, been printed on this subject, why should we doubt, that the circulating fluids can add a particle in the place of one that has been carried off, or that an artery can supply what has been absorbed by a lymphatic vein? As it is granted that the secretion of all other kinds of matter in the bodies of animals is performed by the branches of the arteries, is it not incredible, that there should be an exception to the general rule in the secretion of the nourishment? Surely that power which can convert the food into blood, and can change the blood into bile and semen, is sufficient to convert it into nourishment.

6. I have endeavoured to show that the red colour produced by madder in the bones, or in their callus, in a living animal, is owing to a secretion from the arteries.

I have further observed, that callus and cicatrice are as readily produced in the hind legs of a frog, after cutting, transversely, its spinal marrow or sciatic nerve, as when the nerves are entire. I will now add, that, in calli, cicatrices, or accretions, there are numberless new-formed vessels filled, in the living animal, with red blood, and which can readily be injected*. Nay, I found, by the following experiment, proof of a fact which it was difficult to ascertain by the application of the microscope, to wit, that such new-formed vessels, produced from the opposite sides of a wound, unite into continued canals or anastomose. I made, first, a longitudinal incision through the skin, and muscles, and peritoneum of the abdomen of a living pig. I then sewed together accurately the sides of the wound, and, after some weeks, found that they were firmly reunited. I then killed the pig, and made a longitudinal incision into its abdomen, parallel with, and about

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* See Tab. XLVI.

two inches distant from the former incision, and two transverse incisions, intersecting the longitudinal incisions lower than the upper end, and higher than the under end of the cicatrix. By this means I had surrounded an oblong square portion of the containing parts of the abdomen by my incisions. Yet when, after all, I threw an injection into the aorta, I found it had filled a number of vessels in the oblong square portion *.

If then, in a callus, new earthy or osseous fibres, and new vessels, can be formed by the original arteries, must we not believe that the waste of this earth, and of those vessels, can be ever after supplied by the arteries which formed them? If so, are we not to conclude that the waste of other arteries, and of other organs, is supplied in the same manner from the arteries?

7. If the quantity of blood naturally circulating through a limb be diminished, as by tying the trunk of the brachial artery in the operation for an aneurism, the arm loses part of its strength and size; but the loss is less than, at first sight, might be expected, because the anastomosing canals soon come to be greatly enlarged.

Upon the whole, I apprehend, there are few points in physiology so clear as,

1. That the arteries prepare and directly secrete the nourishment in all our organs.

2. That the nerves do not contain nor conduct the nourishment, but, by enabling the arteries to act properly, contribute indirectly to nutrition.

C H A P.

* See Tab. XLVII.

CHAPTER XXVI.

Of Sensation.

HAVING endeavoured to prove that the nerves serve only for sensation and motion, I shall next treat of circumstances which relate to the exercise of each of these two functions: And first, of Sensation.

When an impression is made on any organ, the nerves of which are entire and connected with the brain, we feel, and are conscious of the impression: But if a nerve is cut, even at its exit from the cranium, or if the structure of the spinal marrow is injured at its upper end*, we are not conscious of any injury done to our organs beyond the place where the nerve is divided. Hence authors, not without the appearance of reason, have supposed, that the living and feeling principle, which we commonly call the mind of the animal, is seated within the head, and occupies there a sensorium commune.

But although, beyond the place at which a nerve is cut, or in a member amputated, a wound does not excite pain; yet, in consequence of that wound, effects follow which we cannot account for on mechanical principles.

Thus, a slight puncture of the heart of a frog, separated from its body, throws all its fibres into violent motion. Such a cause appears to disproportionate to its effects, that we cannot help conceiving that some living principle has been influenced: Or that there are two kinds of feeling, one with, and another without consciousness; the latter, perhaps, resembling

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* Of this I have seen one remarkable example.

that kind of feeling which we must suppose inherent in vegetables, and in consequence of which their vessels are so actuated as to produce still more numerous and wonderful changes on the fluids they convey and secrete, than are to be observed in the animal kingdom.

Before venturing to be more explicit, we shall proceed to consider the other primary office of the nerves, to wit, their enabling the muscular organs to act.

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C H A P.

CHAPTER XXVII.

Of the Termination of the Nerves in the Muscular Organs ;
and whether Muscles possess a Vis Infita different from the
Vis Nervea.

SECTION I.

SOME eminent writers have supposed that the muscular fibres are the continuation of, or are formed by the nerves *, and of late years they have been called the moving extremities of the nerves.

But the following circumstances are inconsistent with such an hypothesis.

1. Muscular fibres, in consequence of their office, have considerable strength and toughness ; whereas the nerves, even when covered with their pia mater (which those very authors suppose them to lay aside at their terminations) are pulpy and soft.

2. That matter which we know for certain to be medullary or nervous, does not appear to be endowed with the power of contracting when irritated.

3. As the nerves consist of threads laid parallel to each other, and which do not, like the blood-vessels, divide into branches, the bulk of which greatly exceeds that of the trunks which produce them, how are we to conceive that a small nerve can form a large mass of flesh?

4. If

* Cole, Santorinus, Boerhaave, Infl. p. 395.

4. If the muscles were formed by the extremities of the nerves, they should shrink very remarkably on cutting the nerves, instead of which, I have observed no sensible alteration in the appearance of the muscles of the thigh and leg of a frog upwards of a year after I had cut across its spinal marrow or sciatic nerves.

Muscles, or muscular fibres, seem, therefore, to be organs *sui generis*, not produced by the nerves, but merely influenced by the energy they convey.

S E C T. II.

NOTWITHSTANDING the above conclusion, that the muscles are machines, the essential basis of which is not derived from the termination of the nerves, we ought not, I apprehend, to adopt the idea of Dr Haller, that muscles are not only thrown into action by the *vis nervea*, but act also by a *vis insita*, differing from, and unconnected with the *vis nervea*.

The chief experiment which seems to have led Dr Haller to this opinion, is the well known one, that the heart and other muscles, after being detached from the brain, continue to act spontaneously, or by stimuli may be roused into action for a considerable length of time; and when, says Dr Haller, it cannot be alledged that the nervous fluid is, by the mind, or otherwise, impelled into the muscle.

That, in this instance, we cannot comprehend by what power the nervous fluid or energy can be put in motion, must, perhaps, be granted. But, has Dr Haller given a better explanation of the manner in which his supposed *vis insita* becomes active?

If it be as difficult to point out the cause of the action of the *vis insita* as that of the action of the *vis nervea*, the admission of that new power, instead of relieving, would add to our perplexity.

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We should then have admitted, that two causes, of a different nature, were capable of producing exactly the same effect, which is not, in general, agreeable to the laws of nature.

We should find other consequences arise from such an hypothesis, which tend to weaken the credibility of it. For instance, if, in a sound animal, the vis nervea alone produces the contraction of the muscles, we will ask what purpose the vis infinita serves?

If both operate, are we to suppose that the vis nervea, impelled by the mind or living principle, gives the order, which the vis infinita executes, and that the nerves are the internuntii, and so admit two wise agents employed in every the most simple action?

But, instead of speculating farther, let us learn the effects of experiment, and endeavour from these to draw plain conclusions.

1. When I poured a solution of opium in water under the skin of the leg of a frog, the muscles, to the surface of which it was applied, were very soon deprived of their power of contraction. In like manner, when I poured this solution into the cavity of the heart, by opening the vena cava, the heart was almost instantly deprived of its power of motion, whether the experiment was performed on it fixed in its place, or cut out of the body.

2. I opened the thorax of a living frog, and then tied or cut its aorta, so as to put a stop to the circulation of its blood.

I then opened the vena cava, and poured the solution of opium into the heart, and found not only that this organ was instantly deprived of its powers of action, but that, in a few minutes, the most distant muscles of the limbs were extremely weakened. Yet this weakness was not owing to
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the want of circulation, for the frog could jump about for more than an hour after the heart was cut out.

In the first of these two experiments we observe the supposed *vis infinita* destroyed by the opium, in the latter the *vis nervea*; for it is evident that the limbs were affected by the sympathy of the brain, and of the nervous system in general, with the nerves of the heart.

3. When the nerve of any muscle is first divided by a transverse section, and then burnt with a hot iron, or punctured with a needle, the muscle in which it terminates contracts violently, exactly in the same manner as when the irritation is applied to the fibres of the muscle. But when the hot iron or needle is confined to the nerve, Dr Haller himself must have admitted that the *vis nervea*, and not the *vis infinita*, was excited.

But here I would ask two questions.

First, Whether we do not as well understand how the *vis nervea* is excited when irritation is applied to the muscle, as when it is applied to the trunk of the nerve, the impelling power of the mind seeming to be equally wanting in both cases?

Secondly, If it appears that irritation applied to the trunk of a nerve excites the *vis nervea*, why should we doubt that it can equally well excite it, when applied to the small and very sensible branches and terminations of the nerve in the muscle?

As, therefore, it appears that the supposed *vis infinita* is destroyed or excited by the same means as the *vis nervea*, nay, that when, by the application of opium to the heart of a frog, after the aorta is cut and the circulation interrupted, we have destroyed the *vis infinita*, the *vis nervea* is so much extinguished, that the animal cannot act with the distant muscles of

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the limbs, and that these afterwards grow very torpid, or lose much of their supposed vis infita, it seems clearly to follow, that there is no just ground for supposing that any other principle produces the contraction of a muscle.

4. An ingenious gentleman, Dr Thomas Smith physician at Birmingham, who, in 1767, published, in this place, an excellent Inaugural Dissertation on muscular action, after having read, in manuscript, an account of the above experiments on opium, which I had communicated to the Philosophical Society of Edinburgh in 1761, and which were published 1771, *Phys. Ess.* Vol. iii. *; and after having, in 1764, when he did me the honour of attending my lectures, heard the above application of them, has proposed the same opinion, that there is no vis infita different from the vis nervea; adding, in farther confirmation of it, that saline bodies, and particularly common salt, which powerfully excite the supposed vis infita when applied to the muscles, had a similar effect on the vis nervea when applied to the trunk of the nerves.

5. Before quitting this subject, I would observe, that, if it shall appear that muscles, when irritated, possess some degree of vibration many days after their nerves have been cut, this may be explained from attending to the facts formerly mentioned, with the view of proving that the nerves, in their whole course, resemble the brain in structure, and, as they proceed, receive an addition of nervous energy.

C H A P.

* See Dr T. Smith's *Tentamen Inaugurale*, Edin. 1767, p. 45.

C H A P T E R XXVIII.

Of the Manner and Causes of the Actions of the Muscles.

I N the *first* place, we know that by far the greater number of motions we perform seem to be regulated by the will; and hence the muscles, which perform these motions, have been very generally called voluntary muscles.

Other motions seem to be spontaneous. In some of these, we are sensible of a stimulus, or uneasiness, which precedes the motion; in others, this stimulus is overlooked or not to be felt. In almost none of them are we conscious that our will interposes in directing the mode of action. Nay, it is evident, that we cannot suppose that the will interposes in directing the mode; because, not only the muscles themselves, but the effects of them, are unknown to us.

To illustrate this subject, I shall briefly enumerate the chief spontaneous motions of animals, in the order in which I apprehend they ought to be arranged when we mean to investigate their causes.

S E C T. I.

I SHALL begin with those examples in which the irritation that produces the motion is at a distance from the muscles which perform it, and, by degrees, proceed to those in which the active organ is directly stimulated.

1. The iris is contracted in proportion to the quantity of light which impresses the retina, if the retina is in a sound state.

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But in some cases of hydrocephalus internus, in which the retina seemed to have very little sensibility, I have seen the pupil remarkably dilated when the eye was exposed to a bright light, and, when the light was removed, it was sensibly lessened *.

When a person examines an object brought near to the eye, the pupil is contracted, although the object be of a black colour, so as not to affect the eye by an increase of light. With this observation let us connect another, to wit, that, when a small printed book is brought so near the eye, that its letters begin to seem confused and intermixed, if we interpose a card, with a very small hole in it, the letters are again seen distinctly.

In one species of bird, the parrot, I long ago remarked, that the pupil was affected by the passions of the mind of the animal, independent of the light upon the eye.

2. When a sound is made suddenly, not only the external ears of a quadruped are moved, but it has been, with great probability, supposed, that the internal muscles of the ear act at the same time.

3. If the nose is violently irritated, we sneeze; if the throat or stomach, we vomit; if the inner membrane of the lungs, we cough; if the rectum or gravid uterus, the containing parts of the abdomen contract strongly and readily. Every one of those actions is complex, yet regular.

4. The motion of the blood in the lungs, and a proper change of air, are promoted by ordinary respiration. But, according to the quality or quantity of the blood or air within the lungs, we may observe the manner of respiration varied.

5. By

* I showed this, in one case, to Dr N. Spens in 1770; and in another, very lately, to Dr D. Rutherford.

5. By the irritation of the external organs of generation, the discharge of the semen is made in the male ; and, in the female, the uterine tubes lay hold of the ovaria.

6. When the bladder of urine is to be emptied, a pressure is first made upon it by the contraction of the diaphragm and abdominal muscles ; afterwards, by the steady and uniform contraction of its own muscular coat, the urine is propelled.

7. When wholesome food is received into the stomach and intestinal tube, these perform elegant and complex motions, called peristaltic and antiperistaltic.

8. If, instead of ordinary food, a hurtful substance is taken into the stomach, the antiperistaltic motion gets the better of the peristaltic, and comes to be assisted by the distant muscles, which are so situated as to be able to compress the stomach, or the person vomits. But, when the hurtful matter is within the colon, or rectum, whether it has descended from above, or been injected from below, the peristaltic motion is greatly increased, and the substance is discharged downwards.

In the pecora, for instance, in the cow, we find not only a complex structure and action of the four stomachs, but that action will be found to be varied according to the kind of food, or the changes it has undergone. The cow fed on grass ruminates, or chews the cud ; but, in the calf, whilst fed on milk, I have not observed rumination ; yet, from the quantity of milk the calf sucks, there can be no doubt that the first stomach serves as a receptacle for the milk. In the cow, then, the crude grass passes from the mouth into the first stomach, and is afterwards, in ruminating, brought back into the mouth, in order to be more thoroughly chewed. When swallowed a second time, it is conveyed into the second, and from it into the third and fourth stomachs. But the milk passes from the first stomach

of the calf directly into the other stomachs. Nay, from the structure of a gutter which leads from the oesophagus, through the several stomachs, it is evidently intended that drink should, on particular occasions, pass from the oesophagus directly into the third or fourth stomachs, without entering the first or second stomachs.

In like manner, in quadrupeds and birds, the intestina caeca must be filled by a regular action of the muscular coat upwards, and emptied by that motion reversed.

10. When the blood irritates the auricle or ventricle of the heart, these contract with so sudden a jerk, that the blood is thrown from them nearly in the same manner as if a blow had been given to these organs by an external agent. Hence, perhaps, we cannot, as Dr Hales has supposed, determine the force of the heart by observing the height to which the blood ascends in a tube inserted into a large artery, or we shall only be able to determine that when we can reduce to calculation the effect of the vis percussio-
nis.

The force and frequency of the action of the heart are generally proportioned to the quantity and quality of the blood. But, when a very great quantity of the blood has been lost by a wound, the pulse becomes more instead of less frequent. From which we may observe, that the action of the heart is regulated not merely by the quality or quantity of the blood, nor by the distension of the sides of the heart, but also by the uses which an increase of the frequency of its actions may serve.

The action of the heart is also greatly influenced by the passions of the mind.

11. When

11. When the muscle of a living animal is laid bare, and punctured, or otherwise irritated, it acts somewhat in the way the subcutaneous muscle of a horse does when his skin is stung by a fly.

12. Several of the above mentioned actions are varied in force and frequency after the mind has been disturbed by its proper passions:

13. Over some of these actions the will possesses power, as over respiration. This power is not, however, absolute, but limited.

S E C T. II.

AN unprejudiced reader, after reviewing these facts, would probably be much surpris'd to learn, that men of genius and knowledge had attempted to prove, that such various and complicated actions were produced by the mechanical structure of the bodies of animals; and, particularly, that they chiefly, or entirely depended on the connection which our different nerves have with each other, by being inclosed in the same sheaths of the dura and pia mater, or by being joined in ganglia.

Whilst such notions were prevalent in some part of this, as well as in other universities, I thought it necessary, in order to detect the fallacy more clearly, to treat of the subject at considerable length, and to state and consider all the principal examples of sympathy mentioned by authors, and to point out the real causes of the various actions. But as, of late years, such theories have been gradually losing ground, and are now become almost obsolete, I shall content myself with copying verbatim the general heads of my objections to the doctrine of such sympathy on mechanical principles, on which I have lectured in 1758, and from that to the present time.

That we are not, from connection of nerves, to explain the regular motions of our different organs produced by gentle and usual stimuli, is proved by the following observations.

1. Muscles

1. Muscles supplied by the nerves irritated, often do not act, but others at a distance. Thus, when the outside of the fore-arm is burnt, not the extensors, but the flexors of the fore-arm act and remove it from the offending cause.

2. Muscles most connected by their nerves do not sympathise most.

3. Sympathy is not to be traced the reverse way.

4. Muscles supplied by intermediate nerves are at rest.

5. The same nerve, irritated in different parts, produces different motions.

6. The same nerve, gently and violently irritated, produces different motions.

7. The same nerve accustomed to the stimulus, acts less, or not at all.

8. Antagonist muscles receive nerves from the same roots.

9. There are many sympathies where a connexion of nerves is not to be traced.

10. Many impulses affect the mind first.

11. Affections of the mind, without the presence of external objects, produce the same effects*.

Upon

* As the late ingenious Dr Whytt, in 1765, published a Treatise on the Sympathy and Diseases of the Nerves, in which many of the above arguments against the then common account of the cause of the

Upon the whole, it appears, 1st, That the actions above mentioned cannot be accounted for on the yet known principles of mechanism.

2^{dly}, We observe, that the muscular fibre varies its operation according to the purpose to be served. That, for instance, when a muscular fibre is punctured, it vibrates, which is the fittest means of throwing off the offending cause; that the alimentary canal, acted on gently by the food, performs a very complex peristaltic motion; that the abdominal muscles act slowly and steadily in expelling the contents of the rectum, but suddenly and convulsively in vomiting; that the bladder of urine, from which there is a small outlet, performs a slow and uniform contraction in discharging its contents; whilst the heart contracts with a jerk.

3^{dly}, The more we consider the various spontaneous operations, the more fully we shall be convinced that they are the best calculated for the preservation and well-being of the animal.

Hence we are led to the conclusion, that they must be directed and conducted by a wise agent, intimately acquainted with the structure, and with all the effects it is capable of producing.

For the purposes of physic, it may, perhaps, be sufficient to know the stimuli which excite the spontaneous motions; the manner in which they are performed; and to be convinced that we cannot account for them from the known texture of the body, or from the yet known principles of mechanism.

C c

But

the sympathy of nerves are mentioned, I think it necessary to observe, that I had delivered all the above arguments in my course of lectures, eight years before Dr Whytt printed on that subject, and three years before he wrote and delivered lectures upon it.

But as those philosophers, who have endeavoured to point out the nature of the agent which directs these motions, appear to me to have fallen short of their mark, I cannot help venturing one step farther.

S E C T. III.

ONE class of philosophers has supposed that our mind, intimately acquainted with the texture of the body, reasons upon, and thereafter performs the several actions *: Whilst philosophers of another class suppose the mind to be the agent, yet deny that she understands the texture of the body, and, therefore, make a conclusion, not very intelligible, that the mind is *necessitated* to act in certain ways †.

As many actions are obedient to our will, we are, at first sight, very apt to suppose that our mind is the sole agent in those actions; and, by an easy transition, to infer that the mind is the sole agent in all our actions.

But, when we reflect, we find that we are only conscious of having willed or wished that a certain action, the bending of the fore-arm, for instance, were performed; but without being conscious of the structure of the muscles employed, or even being sensible of any effort made by our mind for the purpose of determining nervous energy into them. Though, therefore, the mind is conscious of willing to perform certain motions, yet there is less certainty than seemed to be at first sight, that the nervous energy is, by our mind alone, thrown into the muscles which are fit for executing those motions.

But if we are doubtful that the mind is the sole or chief agent in the voluntary actions, we must be still more so with respect to the spontaneous actions, as, in most of these, we are so far from willing that certain motions should be performed in a particular way, that we have no knowledge of their being at all performed.

Unless,

* Stahl, and his followers.

† Dr Whytt on Vital and Involuntary Motions.

Unless, therefore, we suppose the mind to possess powers of which it has no consciousness, these actions cannot be alledged to be directed by it.

But further, unless we suppose the mind to be an intelligent being, possessing innate knowledge, or far more knowledge than it could have acquired by experience, we must refer these operations to some higher source.

A child, at birth, breathes in the most regular manner; cries when hurt; sucks, swallows, coughs, sneezes, vomits, expels the faeces and urine, &c. yet all these are complex actions of which it has had no experience.

The account which some of the most eminent authors have given of the cause of these functions, on mechanical principles, or principles which may be called mixed, as including certain feelings with mechanism, must, when duly considered, appear unphilosophical in the highest degree.

Thus, Dr Haller accounts for the first respiration of a child after birth, by supposing that it has been dreadfully mauled in the time of birth, and that it is endeavouring to express its hurts by crying*, or that, in quest of the liquor amnii, it takes down the air by chance†.

Now, without observing that a child, or the mature foetus of any animal, extracted by the Caesarean operation, breathes in the same manner as when delivered in the ordinary way, I would say that crying is a more complex operation than ordinary respiration; and I would ask two questions, *first*, Who inspired the child with the desire or instinct of crying, or of expressing the need it has of assistance? And, *next*, How the child knew the manner of crying?

Dr

* Haller, Com. in B. Pr. Tom. v. P. 2. pag. 464.

† Haller, El. Phys. Tom. iii. L. 8. p. 318. 'Cibum quaerit in quo natabat, aërem invenit, caeterum non excludo quiritationis molimina.'

Dr Haller, then, instead of solving the problem he had undertaken, merely starts another, equally difficult of solution, depending on similar principles.

In like manner, Dr Haller tells us, that a child after birth can swallow, because, before birth, it was in the practice of swallowing the liquor amnii. But supposing the liquor amnii to be swallowed, I would ask how it got down the first mouthful it took of that liquor? And how, immediately after birth, it sucks, sneezes, coughs, &c. functions of which there could have been no experience in the womb?

* When we throw into the scale the various effects of what has been commonly called the instinct of animals, does it not appear, that the most just, as well as most becoming conclusion we can draw, is, that the Power which created all things, which gave life to animals and motion to the heavenly bodies, continues to act upon, and to maintain all, by the unceasing influence of a living principle pervading the universe, the nature of which our faculties are incapable of duly comprehending?

EXPLANATION

EXPLANATION
OF THE
TABLES.

T A B L E I.

THIS table shows, in a foetus calf, the structure of a plexus formed by the internal carotid artery, called by Galen Rete Mirabile.

A The top of the arteria carotis communis.

B External carotid arteries.

C Several arteries which supply the place of the single internal carotid in man.

D Numerous small serpentine branches into which these arteries are subdivided in their progress through the cranium.

E These branches joining again into F, the principal trunk of the internal carotid artery within the head, and which afterwards divides into branches resembling those in the human subject.

T A B L E II.

IN this table the human cranium, the brain, and the nose, are represented cut perpendicularly, close to the right side of the falx cerebri and septum narium.

AA The section of the cranium.

B Part of the right frontal sinus.

C Part of the right sphenoidal sinus.

D The nasal lamella of the ethmoid bone; E the vomer; and F a cartilage, composing the septum narium.

G The opening from the left side of the nose into the throat.

H The roof of the mouth and teeth of the left side of the upper jaw.

I Cancelli of the cuneiform process of the occipital bone, and from it, upwards to the sella turcica K, numerous and large cancelli were continued in this subject.

LL The root of the falx.

MM The inner side of the left hemisphere of the brain.

N A section of the corpus callosum.

O The septum lucidum.

P The body of the fornix.

QQ The two anterior crura of the fornix.

R A section of the commissura cerebri anterior.

S The passage by which the lateral ventricles of the brain communicate with each other, and with the third ventricle.

T The left side of the third ventricle situated under the left thalamus nervi optici.

U The infundibulum at the bottom of the third ventricle.

V The glandula pituitaria lodged in the sella turcica.

W A section of the right optic nerve.

X A section of the right corpus albicans behind the infundibulum.

Y Part

EXPLANATION OF THE TABLES.

107

Y Part of the choroid plexus.

Z The pineal gland with two peduncles, one of which connects it to the side of the third ventricle, and the other to *a*, which is a section of the commissura cerebri posterior.

b The iter ad quartum ventriculum.

c d A section of the nates and testis.

e The valvula Vieussenii.

f The arbor vitae of the cerebellum.

g The cavity of the fourth ventricle.

h The bottom of the fourth ventricle shut by the vascular or choroid plexus and pia mater.

i A section of the tuber annulare.

k The basilar artery.

l A section of the medulla oblongata.

m A section of the upper part of the spinal marrow.

TABLE

T A B L E III.

THE figures in this table represent the communication of the lateral ventricles of the human brain with each other, and with the third ventricle.

Figures I. and II. represent part of the bottom of the right lateral ventricle, with the fore part of the fornix, and a part of the septum lucidum and corpus callosum. The anterior parts are turned towards the top of the table.

In both FIGURES,

A Represents the fore part of the right corpus striatum.

B Part of the centrum semicirculare geminum.

C The fore part of the right thalamus nervi optici.

D The fore part of the body of the fornix.

E The fore part of the right choroid plexus.

F A natural passage by which the lateral ventricles communicate with each other and with the third ventricle. This passage is bounded on the fore part by the anterior crura of the fornix; above, by the fore part of the body of the fornix, where it is about to form its anterior crura; behind by the meeting of the choroid plexuses of the two ventricles; below, by the thalami nervorum opticom. Two veins, which are more constant in their situation than such small veins are generally, at this place, run into the choroid plexus; one of them comes from the fore part of the septum lucidum, and is over the communication; the other is from the corpus striatum, and runs from it inwards and backwards to the choroid plexus.

M Represents a part of the corpus callosum, between the cut edge of which, and the body of the fornix D, a part of the septum lucidum is seen,

feen, with vessels running on its pia mater, but without any hole or passage through it.

FIG. III. Represents the communication between the lateral ventricles laid open by cutting the fore part of the body of the fornix. By such a section, the hole or passage appears by which the lateral ventricles communicate with the third ventricle.

A The fore part of the left corpus striatum.

C Part of the left thalamus nervi optici.

D The cut body of the fornix between two pins. The undermost is lying in the passage by which the lateral ventricles communicate with each other.

F Is a hole or passage leading down into the third ventricle, by means of which, therefore, the two lateral ventricles communicate with the third ventricle.

FIG. IV. Is a rude sketch, from memory, of the size and shape of the communication between the lateral ventricles, which I observed in the case of a girl of three years old, in the year 1753, where more than two pounds of water were found in the ventricles.

FIG. V. Is a rude sketch taken from the third and fourth ventricles of a child of two years of age, in which half a pound of water was contained in the ventricles. Both these ventricles marked 3 and 4 were sensibly dilated.

At F, part of the dilated passage from the lateral ventricle is rudely sketched.

T A B L E IV.

IN this table farther views are represented of the communication of the lateral ventricles of the human brain with each other, and with the third ventricle. The anterior parts are here turned towards the bottom of the table.

FIGURES I. and II.

AAAA Represents the fore part of the corpus striatum.

BBBB The centrum semicirculare geminum.

CCCC The thalami nervorum opticom.

DD The body of the fornix.

EEEE The choroid plexuses.

FF Fig. I. A crooked pin passed through the passage by which the lateral ventricles communicate with each other.

F Fig. II. Shows the hole or passage under the middle of the communication of the lateral ventricles with each other, by which the lateral ventricles communicate with the third ventricle.

GG Fig. II. The anterior crura of the fornix.

FIG. III. In this figure the fornix, which was represented in Fig. II. cut across, is represented raised and turned backwards.

BB The centrum semicirculare geminum.

CC The thalami nervorum opticom.

D The under part of the body of the fornix, which was cut across and turned back.

EE The choroid plexuses of the two ventricles.

F The passage by which the lateral ventricles communicate with the third.

GG The

EXPLANATION OF THE TABLES. iii

GG The anterior crura of the fornix.

HH A membrane, with many vessels containing red blood, which covers and conceals the third ventricle, ties together the choroid plexuses, and adheres so closely to the thalami nervorum opticorum as to allow under it no communication of the lateral ventricles with the third ventricle.

The letters HH are placed at two principal veins of this membrane, and which, farther back, unite to form a vein which terminates in the torcular Herophili, and which was observed by Galen, and has been named after him Vena Galeni.

TABLE

T A B L E V.

IN this table a view is given of the human crura cerebri and cerebelli, of the tuber annulare, and medulla oblongata, after dissecting away from them the arachnoid coat and pia mater, in order to show the general direction of their medullary fibres.

AA. BB. CC The anterior, middle, and posterior lobes of the brain, slightly sketched.

DD The hemispheres of the cerebellum.

EE The superior and anterior vermiform processes of the cerebellum.

FF The two optic nerves cut horizontally.

G The intimate intermixture of their medullary substance.

HH The optic nerves cut across near the foramina optica.

II Cineritious substances intimately connected to the optic nerves, and furnishing some part of their medullary substance; between these there is a fissure through which the pia mater and blood-vessels pass.

K A section of the infundibulum.

LL The corpora albicantia behind the infundibulum.

MM The crura cerebri consisting, on their surface, of bundles of medullary fibres.

N A cineritious substance joining the crura cerebri and corpora albicantia of opposite sides of the brain.

OO The principal crura cerebelli.

PP The tuber annulare, or pons Varolii, the surface of which consists of medullary fibres laid chiefly in transverse bundles.

QQ

QQ Anterior, oblong, and somewhat pyramidal bodies, composed on their surface of bundles of medullary fibres, disposed transversely, and passing from one side of the medulla oblongata to the other side of it, or joining these two pyramidal bodies intimately together. Between these pyramidal bodies there is a fissure above a quarter of an inch deep, into which the pia mater enters, and, still deeper, vessels pass between the decussating bundles of medullary fibres.

RR The bodies called commonly olivaria.

SS A small part seen of oblong medullary and somewhat pyramidal bodies, which form the back part of the medulla oblongata.

T The end of the medulla oblongata, or top of the spinal marrow.

Ff

TABLE

T A B L E VI.

THIS table represents a perpendicular section in the human subject, of the corpus striatum, thalamus nervi optici, crus cerebri, tuber annulare, pineal gland, commissura cerebri posterior, nates, testis, cerebellum, and fourth ventricle, with the back view of the medulla oblongata.

AA The under or inner side of the corpus callosum.

B The top of the corpus striatum.

C The centrum semicirculare geminum.

D The top of the thalamus nervi optici.

EF A perpendicular section of the corpus striatum and thalamus nervi optici.

G A perpendicular section of the crus cerebri.

H A perpendicular section of the tuber annulare.

I The iter a 3tio ad 4tum ventriculum.

K The middle of the fourth ventricle.

L The bottom of the fourth ventricle shut by the vascular or choroid plexus.

M The section of the commissura cerebri posterior.

N The section of the pineal gland which adheres to the brain by two medullary peduncles.

OP The nates and testis

Q The medullary part of the cerebellum, called Arbor vitae.

R The valvula Vieussenii, a medullary substance covered with cineritious matter.

SS The two posterior oblong somewhat pyramidal parts which compose the medulla oblongata, and which are separated from each other to about the depth of a quarter of an inch, by a fissure, into which the pia mater enters.

T Transverse medullary bundles joining the two pyramidal columns.

U The bottom of the medulla oblongata or upper end of the spinal marrow.

T A B L E

T A B L E VII.

IN Fig. I. is represented a section of the human brain and cerebellum, with their crura, the tuber annulare and medulla oblongata, in order to show a great intermixture of cineritious substance with the medullary, and very various directions and interlacing of the bundles of the medullary fibres.

AB The anterior and middle lobes of the brain cut.

C The posterior lobe of the brain entire.

DD The hemispheres of the cerebellum.

E The corpus striatum.

F The thalamus nervi optici.

G One of the corpora albicantia composed of a medullary crust containing cineritious matter.

H The crus cerebri.

I The crus cerebelli.

K The tuber annulare cut perpendicularly from right to left.

L The tuber annulare cut perpendicularly from before backwards to more than the depth of a quarter of an inch.

MNO The medulla oblongata cut perpendicularly from right to left.

P The medulla oblongata entire on the left side of the fissure into which the pia mater enters.

Q The end of the medulla oblongata, or top of the spinal marrow.

FIG. II. Represents a transverse or horizontal section of the beginning of the spinal marrow, in which A and B represent the anterior and posterior fissures into which the pia mater enters.

CCDD Cineritious matter, of a cruciform appearance, inclosed in medullary substance.

EE The joining of the two chords which compose the spinal marrow.

T A B L E

T A B L E VIII.

THIS table represents the heads of children born at the full time, in which the bones, which generally form the top of the cranium, are wanting, and in which the brain, which is extremely small, projects like an excrescence.

ABCD An oblong square portion in which there is no bone.

EF The hemispheres of the brain appearing in the form of excrescences from the top of the head, and over which the common teguments were remarkably thin and imperfect.

G In Fig. II. Represents the back part of the two hemispheres joined inseparably together.

In Fig. III. The excrescences E F, which supply the place of the brain and cerebellum, are extremely small.

T A B L E

T A B L E VIII. *

IN this table, the brain found in an imperfect state, in two children, and the nerves of the head, neck, and arm, are represented.

FIGURE I.

AB Two projections, or excrescences, which supplied the place of the hemispheres of the brain.

C A red coloured firm substance which supplied the place of the cerebellum.

D Part of the occipital bone turned out of its place.

E The sheath of dura mater which inclosed the spinal marrow.

F The spinal marrow of the neck and cervical nerves taking their rise from it.

G The left eye-ball.

H The left optic nerve.

I The joining of the two optic nerves.

J K The third and fourth pairs of nerves.

L The root of the fifth pair of nerves.

M The ganglion of the fifth pair.

N The ocular branch of the fifth pair.

O The superior maxillary branch of the fifth pair.

P The inferior maxillary branch of the fifth pair.

Q The proper inferior maxillary branch, and branches sent from it to the teeth.

R The lingual branch of the fifth pair.

S The sixth pair of nerves.

T The portio dura of the seventh pair.

V The eighth pair, and U its pars vaga.

G g

W The

118 EXPLANATION OF THE TABLES.

W The ninth pair.

X The great sympathetic nerve.

FIG. II. Shows the upper part of the hemispheres of the brain and the optic nerves.

AB The hemispheres of the brain.

CD The eye-balls.

E The dura mater.

F The joining of the optic nerves.

FIG. III. A The sternum.

BC The two shoulders.

D The external ear.

EFGH The throat, chin, mouth, and nose.

IK The right and left hemispheres of the brain.

L The left eye.

MN The subclavian artery cut transversely, that the nerves may be better seen.

O The left carotid artery.

PQ The pars vaga of the eighth pair, and the great sympathetic nerve.

RS The fore part of the spinal marrow.

T The mastoid process of the temporal bone.

1. 2. 3. 4. 5. 6. 7. 8. The seven cervical subvertebral nerves, and the first subvertebral dorsal nerve, with the origin of the phrenic nerve.

9. 10. 11. 12. 15. 18. 19. 20. The axillary plexus and nerves sent off from it, in the usual manner and of the usual size.

TABLE

T A B L E VIII. **

IN this table are represented the parts of a human female monster, in which there are two heads, and the bones, muscles, and nerves of two trunks, two pairs of lungs, and two stomachs; but only two arms and two legs, two renal glands, and two kidneys, one liver and spleen, and one heart, consisting of one auricle and one ventricle only.

In all the FOUR FIGURES,

a a a a Represents the head on the right side.

b b b b The left head.

c c c c The right arm.

d d d d The left arm.

e e e e The right leg.

f f f f The left leg.

In FIG. I. II. and III.

g Represents the right stomach.

i The left stomach.

k The single tract of small intestines.

l The appendix vermiformis.

m The colon ending in the rectum.

b b The anterior lungs on the right side.

p p The anterior lungs on the left side.

o Fig. I. Two posterior lungs.

q q q The jugular veins forming the superior cava, and ending in the auricle of the heart *u u*.

r In Fig. I. The fore part of the ventricle. *r* In Fig. II. Shows the back part of the ventricle, as the point of the heart is turned upwards.

SS.

120 EXPLANATION OF THE TABLES.

SS. SS A right and left aorta, each forming an arch, as usual, and sending off from it two carotid arteries and the subclavian.

tt A right and left pulmonary artery, each joined by a canalis arteriosus to the aorta.

W The umbilical vein.

X The two iliac veins joining to form the cava inferior.

Y The venae cavae hepaticae, seen by dissecting the liver.

z A vessel resembling the canalis venosus, continued from the umbilical vein, after that vein has been joined by the vena porta abdominalis and has sent off the vena porta hepatica.

** The two pulmonary veins of the anterior lungs ending in the auricle.

AB The right and left renal glands and kidneys.

VV The right and left descending aorta.

FIG. III.

r Represents the ventricle of the heart cut open.

* The communication of the auricle with the ventricle.

SS and tt The aortae and pulmonary arteries, the beginning of which from the ventricle is seen.

CD Represent the diaphragm.

MN Represent the plexus of lumbar nerves of the right side. These on the outer side M, which supply the leg, are much larger than those on the inner side N, which supply the half of the pelvis only.

FIG. IV.

E Represents the posterior sternum.

FG The ribs and the two spines.

HH The right and left os ilium.

I A middle os ilium.

K The anus.

TABLE

T A B L E IX.

THIS table represents the structure of some principal parts of the brain and of the spinal marrow in a sheep.

In FIG. I. The brain is cut perpendicularly on the left side of the septum lucidum.

- A The cranium.
- B The right hemisphere.
- C The corpus callosum cut.
- D The septum lucidum.
- E The body of the fornix.
- F The left anterior crus of the fornix.
- G The left choroid plexus.
- H A probe passed from the left lateral ventricle into the right lateral ventricle, or hole, or passage, by which they communicate with each other and with the third ventricle.
- II A pin passed from the anterior part of the left lateral ventricle into a small ventricle within the olfactory nerve.
- K The fore end of the ventricle of the olfactory nerve.
- L A doubling of the dura mater which surrounds the olfactory nerve.
- M The white or medullary part of the olfactory nerve.
- N Pulpy cineritious substance of the olfactory nerve placed between its medullary part and the ethmoid bone.
- O Part of the convoluted bones within the nose.

FIGURE II.

- AA The hemispheres of the brain.
- B The under part of the middle lobe of the brain.

H h

C A

- C A cut made through the under part of the middle lobe of the brain into the bottom of the left lateral ventricle.
- D The cineritious pulpy part of the right olfactory nerve dissected away from the cribriform plate.
- EE The medullary substance of the left olfactory nerve, part of which is seen coming out of the cut corpus striatum.
- F The ventricle of the left olfactory nerve cut open.
- G The optic nerves incorporated.
- H The infundibulum cut.
- II The crura cerebri.
- KK The tuber annulare.
- LL The medulla oblongata.
- M The medulla spinalis.
- N The cut end of the spinal marrow with the cineritious part in its centre.

FIG. III. Gives a view of part of the basis of the cranium of a sheep.

- AA Processes of the dura mater which surround the olfactory nerve.
- BB Inequalities and holes of the cribriform plates for the passage of the olfactory nerves.
- C The conjoined optic nerves.
- D The glandula pituitaria.
- EE The lodgement of the middle lobes of the brain.

FIG. IV. and V. Show that the spinal marrow is composed of two large cords joined together by ashy coloured substance.

- AA The dura mater covering the spinal marrow.
- BBBB The two principal cords which form the right and left sides of the spinal marrow.
- CC A layer of cineritious substance which joins together the two cords BB.

FIG.

EXPLANATION OF THE TABLES. 123

FIG. VI. and VII. Shew a longitudinal section from right to left of the spinal marrow.

BBBB The two principal cords which compose the spinal marrow.

CCCC The cineritious substance joining these cords together.

FIG. VIII. Represents a transverse section of the spinal marrow of a sheep.

BB The two principal medullary cords.

C Cruciform cineritious substance in the centre of the spinal marrow, by means of which the two principal lateral cords are joined together.

FIG. IX. Represents the infundibulum of an ox, laid open by a perpendicular section of its fore part.

A Represents a transverse section of the optic nerves conjoined.

BB The back part of the conjoined optic nerves, and the fore part of the infundibulum, divided by a perpendicular section.

CC The cavity of the infundibulum. The under part of the funnel is composed of a more vascular and darker coloured substance than the upper part of it.

D. A fissure between the thalami nervorum opticorum, at the upper and back part of the infundibulum.

E An eminence or pifiform process at the upper part of the glandula pituitaria, in which the infundibulum terminates.

FF The internal carotid arteries.

GG The third pair of nerves.

HH Parts of the base of the cranium to which the fore part of the tentorium cerebello superextensum is connected.

T A B L E

T A B L E X.

THIS table represents a fore view of the spinal marrow of a man, after cutting away the bodies of the vertebrae, laying open the sheaths formed by the dura mater and arachnoid coat, and cutting the anterior bundles of the spinal nerves.

AB The sides of the atlas or first vertebra.

CDEF The sheaths formed by the dura mater and arachnoid coat laid open.

G The upper end of the spinal marrow inclosed in its pia mater.

H Its under part at the under part of the second vertebra of the loins.

IK Folds, rugae, or joints of the spinal marrow.

L The cauda equina.

1, 1. 2, 2. 3, 3. 4, 4. &c.

1, 1. Represents the first pair of cervical, or rather subcervical vertebral nerves, &c.

8, 8. Represents the first pair of dorsal nerves.

20, 20. The first pair of lumbar nerves, &c.

M A septum or partition between the holes in the dura mater for the passage of the anterior and posterior bundle of fibres which compose each of the nerves of the spinal marrow.

N The anterior bundle, in its proper hole, covered by a sheath of the dura mater which covers the spinal marrow.

O The posterior bundle with its proper hole and sheath.

P A ganglion in the posterior bundle.

Q The anterior bundle joined to the nerves which issue from the ganglion of the posterior bundle.

RSTU The accessory nerve, taking its rise from the side of the spinal marrow,

marrow, and connected, by filaments, with the posterior bundle of the first and second subvertebral cervical nerves.

VWXYZ Small nerves which join the posterior bundles of the subvertebral cervical nerves to each other.

a, b, c, d, e, f, g, h, i, k, l, m, n, o, p, q, r, s, t, u, v, w, x. The ligamentum denticulatum fixed by a number of small filaments to the pia mater covering the spinal marrow, and, by larger cords, fixed to the dura mater. These cords, in some places, ascend; in others, they descend; in the greater number they are transverse.

w x A substance produced from the end of the spinal marrow, reckoned by many authors a nerve, but which ought to be considered as the under part or termination of the ligamentum denticulatum.

FIG. II. Shews, more fully than in the former figure, the way in which the accessory nerve is connected to the spinal marrow and to the posterior part of the spinal nerve.

T A B L E XI.

IN this table are represented, in a man, (after cutting off the bodies of the dorsal vertebrae) the structure of the surface of the spinal marrow, the rise of the anterior and posterior bundles of the dorsal nerves, a ganglion in the posterior bundle, and the connection of the two bundles with each other, and with the great sympathetic nerve.

AB Represents the spinal marrow covered with its membranes.

2, 3, 4, 5, 6, 7, 8, 9, 10, Represent the second, third, &c. ribs, with the corresponding dorsal nerves.

CDEFG The great sympathetic nerve on the left side. DE The sympathetic nerve cut across, and its ends turned aside. F The ramus splanchnicus. G The continuation of the trunk of the sympathetic nerve.

HH The cellular and fatty substance on the outer side of the dura mater.

I The inner side of the dura mater which is here cut and turned back.

K The pia mater, with the principal anterior artery of the spinal marrow running upon it.

L Plicae or joints in the spinal marrow, by which it may be elongated without being lacerated.

M Part of the substance called ligamentum denticulatum.

N The anterior branch of the fifth dorsal nerve beginning by several bundles of fibres.

O The posterior spinal branch of the fifth dorsal nerve. The anterior and posterior bundles of the spinal nerves pass through different holes of the dura mater, and each receives, from its inner layer, a thin sheath. The two cords are tied together and covered by the cellular substance on the outside of the dura mater condensed, so that they seem to form one cord.

P

EXPLANATION OF THE TABLES.

127

P A ganglion in the posterior branch of the dorsal nerve.

Q Nervous fibres issuing from the ganglion P, and joining with the fibres of the anterior branch so as to form one cord.

R The branches from the dorsal nerves which run to the back, or the posterior dorsal branches.

SS The trunk or anterior branch of the fifth proper dorsal nerve.

T A ganglion of the great sympathetic nerve joined to the proper dorsal nerve by two branches, one of which is fixed to it where it sends off the posterior dorsal branches; the other is fixed to the trunk or large anterior branch.

UVWXYZ Other ganglia of the great sympathetic nerve connected in a similar way.

TABLE

T A B L E XII.

IN the four Figures of this table the parts of a monstrous kitten are delineated of their natural size. It appears to have one head and two bodies, each with four legs, 1, 2, 3, 4, 5, 6, 7, 8.

When we view it with the point of the nose and the mouth towards us, as in Fig. 1. one of the bodies is placed on the right side and the other on the left side. The latter wants the tail.

FIGURES II. and III.

AA Two hemispheres of a brain. B A cerebellum, and C a spinal marrow belonging to the body on the right side.

FIG. IV.

D A spherical body supplying the place of brain and cerebellum to the left body, with

E Fig. IV. A spinal marrow produced from it, of the same size as that to the right body.

FIG. I. and II.

F The tongue fully seen, after cutting open the left side of the mouth and throat.

G The top of the pharynx.

H Fig. I. and II. The oesophagus, common to both bodies.

K In Fig. I. represents the under and fore part of the stomach. K In Fig. II. represents the back part of the stomach, common to both bodies.

L The small intestine dividing into two equal intestines, which terminate in intestina crassa M and N, proper to each body.

Each body has likewise two kidneys, one of which in each body is seen at OO.

Each body has an uterus and vagina which are not delineated. The left vagina terminates in the rectum.

P In Fig. I. represents a common liver, and Q in Fig. II. a common spleen.

R The

R The anterior part of the diaphragm fixed to the ribs as well as to the anterior sternum.

S The posterior part of the diaphragm fixed to the posterior sternum only.

T Fig. I. Lungs which consist of four lobes, on the right side of the heart.

U Fig. I. Lungs consisting of two lobes on the left side of the heart.

These are separated from each other in the usual way by the mediastinum.

X The larynx and trachea from it for conducting the air into the lungs T and U. The whole of the larynx is open towards the pharynx.

VW Fig. II. Lungs, consisting each of two lobes, placed at the sides of the oesophagus I, from which their tracheae are sent off, represented at the letter Y.

The lungs VW are in one cavity, formed by a posterior membrane or pleura. This cavity is divided from the two anterior cavities of the thorax by the intervention of the posterior pleura, connected to the anterior pleurae by cellular membranes. But, as the posterior part of the diaphragm S is connected to the posterior sternum only, and not to the posterior ribs, the posterior cavity of the thorax communicates with the cavity of the abdomen at ZZ, on each side of S.

Both bodies are supplied with blood from one heart.

Two inferior venae cavae, joined with the superior cava, terminate in one auricle *a*.

b Is the right ventricle.

c The pulmonary artery which sends arteries to the four lungs.

d The left auricle.

e The point of the left ventricle, from which one aorta is sent out, which soon divides into *f* and *g*, right and left aortae proper to each body, from the arches of which the ascending branches are sent off.

The canalis arteriosus ends in the left aorta *g*.

The umbilical cords, formed as in two distinct foetuses, are contiguous at *h*, or seem to form one common cord; and as there is but one liver, it is probable that the umbilical veins united within the body.

T A B L E XIII.

ALL the Figures of this table (except the last, viz. Fig. 15.) represent the appearance of the nerves of man, quadrupeds, birds, amphibia, fishes, when carefully viewed with the naked eye, or with a magnifying glass.

FIG. I. II. III. IV. Represent the human nerves.

The uppermost delineations in Figures I. and IV. represent small nerves of an adult, and the uppermost delineation in Fig. III. represents the trunk of the anterior crural nerve of a child.

The delineations placed immediately under these represent the same nerves viewed with a magnifying glass.

Fig. II. Represents part of the sciatic nerve of a child viewed with a magnifying glass.

The third delineation of Fig. I. shews the change of appearance produced by stretching the same nerve moderately.

The fourth or undermost delineation in Fig. I. shews the same nerve stretched as fully as it can bear, without being lacerated.

The nerves, when stretched, not only become smaller, but the serpentine turns which they seem to make when relaxed, become, as the degree of tension is increased, less and less observable till they disappear.

FIG. V. Represents, of their natural size, two small nerves of quadrupeds; the uppermost is from a dog, the undermost from a sheep.

FIG. VI. VII. VIII. Represent the nerves of fowls, of the natural size and magnitude.

FIG. IX.

EXPLANATION OF THE TABLES. 131

FIG. IX. Represents the sciatic nerve of one of the amphibia, to wit, the frog, of its natural size.

FIG. X. Shews the appearance of part of the same nerve viewed with a magnifying glass.

FIG. XI. Shews the appearance of the same nerve fully stretched and viewed with a glass.

FIG. XII. XIII. and XIV. Represent the nerves of fishes.

Fig. XII. Shews, of the natural size and magnitude, a nerve which runs down the side of a haddock, traced in Tab. XXXII. Fig. 1. S.

Fig. XIII. Shows a nerve of the stomach of a skate, of the natural size and magnified.

Fig. XIV. Shews part of the ocular branch of the fifth pair of nerves of a skate magnified: A few spheroidal bodies adhere to these branches.

FIG. XV. Shews, as a general example of the appearance of the tendons in the first four classes of animals, the appearance of one of the tendons of a skate, of its natural size.

T A B L E

T A B L E XIV.

THE two Figures of this table show the appearance of the sciatic nerves twelve months after they had been cut across and rejoined in living frogs.

A The back or upper part of the pelvis.

B The knee.

CD The trunk of the sciatic nerve laid over a couple of pins.

E The re-union of the divided parts of the sciatic nerve, which is of a darker colour than the original nerve. In Fig. I. It is nearly of the same size with the trunk of the nerve.

In Fig. II. It is somewhat larger.

The part of the nerve below the re-union preserved nearly, if not entirely, its natural size.

T A B L E

T A B L E XV.

REPRESENTS the human axillary plexus of nerves on the right side.

AA The five undermost cervical, and two uppermost dorsal vertebrae.

BB The middle scalenus muscle.

C The insertion of the great pectoral muscle in the os humeri.

D The insertion of the small pectoral muscle into the coracoid process.

E The deltoid muscle.

F The long head of the biceps flexor cubiti muscle.

G Its short head from the coracoid process.

H The coracobrachialis muscle.

I The latissimus dorsi muscle.

K The serratus anticus major muscle.

L The triceps extensor cubiti muscle.

M The internal condyle of the humerus.

N The fore-arm.

3, 4, 5, 6, 7. The third, fourth, fifth, sixth, and seventh subvertebral cervical nerves.

1 The first subvertebral dorsal nerve.

8 A branch from the third subcervical nerve to the top of the humerus.

9 The phrenic nerve receiving branches from the third and fourth subcervical nerves, and sending a small branch to the axillary plexus.

10 A trunk formed by the fourth and fifth subcervicals, with a small thread from the third subcervical.

11 The superior posterior scapular nerve, derived from the trunk 10, in its course to the notch in the superior costa of the scapula.

12 The articular circumflex nerve, likewise derived from the trunk 10.

- 13 A large part of the sixth subcervical added to a large nerve from the third, fourth, and fifth subcervicals.
- 14 The joining of the seventh subcervical and first dorsal nerves.
- 15 15 The nerve called spiral muscular, by my Father, or radial of Winflow, formed by the third, fourth, fifth, sixth, and seventh subcervical nerves, and first subdorsal.
- 16 A great trunk formed by the third, fourth, fifth, sixth, seventh subcervical nerves, and the first subdorsal nerve.
- 17 The musculo-cutaneous, or perforans Casserii, proceeding from the trunk 16.
- 18 The radial of Monro, or median of Winflow, from the trunk 16.
- 19 19 The ulnar nerve proceeding from the seventh subcervical and first subdorsal, chiefly, but receiving small branches from the joining of the third, fourth, fifth, and sixth subcervicals.
- 20 The subcutaneous basilic nerves derived from the seventh subcervical and first subdorsal nerve.
- 21 External thoracic nerves from the third, fourth, fifth, sixth, seventh subcervical, and first subdorsal nerves.

T A B L E XVI.

THIS table represents the five undermost cervical subvertebral nerves, with the first dorsal nerve of the human subject, taking their rise from the spinal marrow, and joining to form the brachial plexus, which is fully dissected to shew the connections of its nerves.

A The edge of the trapezius muscle.

B The acromion.

C The lesser pectoral inserted into the coracoid process of the scapula.

D The deltoid muscle.

E The insertion of the great pectoral muscle.

FGH The biceps flexor cubiti muscle.

I The coracobrachialis muscle.

KK The latissimus dorsi muscle.

LL The triceps extensor cubiti.

M The internal condyle of the humerus.

NO Part of the spinal marrow laid in view, by cutting away the bodies of the five undermost cervical and first dorsal vertebrae.

3, 4, 5, 6, 7, 1. The five undermost cervical nerves, and first dorsal, taking their rise, each by two bundles of nervous fibres, to wit, one anterior and one posterior bundle.

8, 8, 8, 8, 8, 8, The anterior bundles of nerves.

9, 9, 9, 9, 9, 9, The posterior bundles of nerves

10, 10, 10, 10, 10, 10, A ganglion formed by the posterior fasciculus of nerves.

11, 11, 11, 11, 11, 11, A bundle of nerves issuing from each ganglion, to be

be joined to the anterior bundle of nerves, so as to form one great nerve, or cord of nerves.

12 A large branch from the third cervical nerve to the upper part of the shoulder.

13, 13 The phrenic nerve, the upper part of which receives threads from the third and fourth cervicals, and sends a small thread to the axillary plexus.

14 The fourth cervical joined by branches from the third and phrenic nerve.

15 The posterior scapular nerve.

16 A large cord formed by a great part of the fourth and fifth cervicals and fibres from the third and phrenic.

17 The axillary circumflex nerve produced from that cord.

18 The sixth cervical, joined by a considerable branch from the seventh.

19 20 The remainder of the seventh cervical, joined by a considerable part of the first dorsal nerve.

21 The muscular spiral nerve of *Monro*, or radial of *Winflow*, receiving branches from, or formed by, all the five undermost cervical nerves.

22 A large cord formed by all the five undermost cervical nerves.

23 The musculo-cutaneous nerve of *Monro*, or perforans of *Cafferius*, derived from the last mentioned cord, or from all the five undermost cervical nerves.

24, 24, 24 The radial nerve of *Monro*, or median of *Winflow*, receiving branches from the five undermost cervical nerves, and from the first dorsal. The several small threads which compose the trunk of this nerve are separated by dissection, to show that plexuses, similar to what is called axillary plexus, are formed by these in the whole progress of the nerve.

25 25 The ulnar nerve derived from the seventh cervical and first dorsal nerves, joined, in this subject, by a thread from the muscular spiral nerve.

26 26 Subcutaneous basilic nerve, derived from the first dorsal, after it has been joined by small branches from the seventh cervical.

27 27 Several external thoracic and cutaneous nerves derived from different parts of the axillary plexus.

T A B L E

T A B L E X V I I .

THIS table represents the axillary plexus of nerves dissected in another subject, and its parts distinguished by the same figures as in the preceding table.

M m

T A B L E

T A B L E XVIII.

THIS table represents the threads which compose the radial nerve of Monro, or median nerve of Winslow, traced by dissection.

AA The threads composing the radial nerve separated from each other near the top of the humerus.

BB The various joinings and divisions of the fibres as they proceed down the humerus.

CCCC Branches sent off to neighbouring parts.

DD The net-work the fibres form in their progress down the fore-arm.

EE At the wrist, the whole nerve grows flatter than it is above, and the threads are more intimately blended.

FG The branches sent to the thumb.

HIKLM Branches to the fore, mid, and half of the ring-finger.

T A B L E

T A B L E XIX.

THIS table is intended to show the way in which the branches of the different nerves of the face are connected.

FIG. I. Shows the way in which a branch of the portio dura of the seventh pair of nerves is connected with a branch of the infra orbital branch of the fifth pair in a man. The diameter of these nerves is represented three times greater than is natural.

A Is a branch of the portio dura.

B Is a branch of the infra orbital nerve.

CDE Are principal branches sent off from the arch which the joining of A and B forms.

C Is chiefly from A, but

D and E are evidently formed by branches of the portio dura A, joined with branches of the infra orbital nerve B.

FIG. II. Represents the joining of the same nerves in the face of an ox.

F Is part of the muscles of the upper lip.

G Is a branch of the portio dura.

HI Are two branches of the infra orbital nerve, sent out at different holes of the superior maxillary bone.

KLM Are three branches sent off from GHI.

K Is formed by a nerve from H joined to a nerve from I.

L and M have each a thread from G, joined to a thread from N, which is formed by H, joined with I. That is, the nerves L and M have threads from the portio dura, and also from both branches of the infra orbital nerve.

At O the portio dura and infra orbital nerves were joined together by a small nerve which formed an arch.

T A B L E

T A B L E XX.

THIS table represents a ganglion in the trunk of the fifth pair of the nerves of the head in man.

FIG. I. Represents this ganglion of the natural size, cut and spread out.

FIG. II. Represents the same magnified.

a or *A* Represents the trunk of the fifth pair.

e *E* The root of the ocular branch.

bcd *BCD* The nervous fibrils traced through this ganglion, separating into smaller threads on one side of it, and these on the other side joining again to form larger fibres.

FIG. III. Represents the surface, and Fig. IV. a section of a part of the same ganglion in another subject.

In both these figures the whole course of the nervous fibrils can be traced.

ee Represents part of the trunk of the fifth pair of nerves.

bc bc Part of the ganglion.

aa Some of the branches coming out of the fore part of the ganglion.

T A B L E

T A B L E XXI.

REPRESENTS different parts of the human great intercostal or sympathetic nerve.

FIG. I. Represents, of the natural size, the uppermost cervical ganglion of the great sympathetic nerve.

FIG. II. Represents the same ganglion, cut longitudinally, and examined with a magnifying glass which increases the diameter about six times.

Bundles of nervous fibres running lengthwise, joining, and again separating, can, for certain, be distinguished within it.

FIG. III. Shows, of the natural size, one of the thoracic ganglia cut longitudinally.

A The ganglion. B One of the branches by which it is connected to the proper intercostal nerve.

FIG. IV. Shows the same ganglion magnified.

In every part of it nervous threads could be traced, with great certainty, as they every where had those regular rugae or folds proper to the nerves.

FIG. V. Shows, of the natural size, the ganglia of the splanchnic branches of the sympathetic nerves, and their joining with each other, and with the eighth pair of nerves, on the fore part of the aorta, where

N n

they

they are said to form femilunar ganglia and solar plexuses. In this subject the ganglia were more numerous than is common.

A The principal branch of the right splanchnic nerve.

B The principal branch of the left splanchnic nerve.

C The principal branch of the eighth pair, which is joined to the splanchnic nerves from the sympathetic.

D The trunk of the aorta.

EF Ganglia in the course of the splanchnic branches, which, in this subject, were more numerous than common.

G The joining of the splanchnic nerves with each other, and with the eighth pair.

HHH Various branches of the solar plexus.

TABLE

T A B L E XXII.

IN this table the structure of the first cervical ganglion of the great sympathetic nerve is delineated in the sheep and ox.

The three first figures represent the structure of that ganglion in a sheep: The three last represent its structure in the ox.

FIGURES I. and IV. Shew the surface of that ganglion, of its natural size.

FIG. II. and V. Shew the same surface as it appears when viewed through a magnifying glass.

FIG. III. and VI. Shew a longitudinal section of it viewed through a magnifying glass.

From *aa* A A A A, to *bb* B B B B, the whole bulk is evidently composed of nervous fasciculi, which, however, repeatedly join, and again separate from each other. On the surface of the ganglion, from B to C, similar nervous fasciculi can be traced, joining and separating again from each other.

In FIG. III. and VI. where these ganglia are cut, their substance seems composed of fibres running longitudinally, which, however, are of a different colour and consistence from the fibres on the surface; for their folds, or joints, within these ganglia, are much less distinguishable. Many large blood vessels G enter into the ganglia.

DE The principal nerves which issue from the lower part of the ganglion, are composed of fasciculi of nervous fibres, collected from all parts of the ganglion.

T A B L E

T A B L E XXIII.

THIS table represents the structure of the thoracic ganglia of the great sympathetic nerve of an ox, and the manner in which these are connected with the proper dorsal or intercostal nerves.

FIGURES I. and III. Represent two thoracic ganglia, of their natural size, cut longitudinally. FIG. II. and IV. Represent the same ganglia, viewed through a magnifying glass.

In all these FOUR Figures,

A B C D E Represent nerves entering the ganglia.

F One of the nerves by which the thoracic ganglion is connected to the proper intercostal nerve.

GG In Fig. I. and III. are the roots of the proper intercostal nerves joined to the ganglia by the branches FF.

L In Fig. III. represents the out side of the fore part of the cut ganglion.

H H H H Represent the inner part of the ganglia, in which, with the magnifying glass, numberless fasciculi of fibres can be distinctly seen, with the plicae, folds, or joints, proper to nerves.

I In Fig. I. and II. a small ganglion, in which likewise nervous fibres can be traced distinctly.

At K K, Fig. II. and IV. where the nerve F connects the ganglion to the proper intercostal nerve, some of the nervous fibres of F are continued with the nervous fasciculi in the upper part of the ganglion, and others of them are continued with nervous fasciculi in the under part of the ganglion.

FIG.

EXPLANATION OF THE TABLES. 145

FIG. V. and VI. Shew in what way the nerves from the thoracic ganglia are joined with the proper intercostal nerves.

Fig. V. Represents the nerves of their natural size; and Fig. VI. shews the same nerves as they appear through a magnifying glass.

At NOP the anterior branch, or, as it is commonly called, the trunk of the proper intercostal nerve, is shewn to consist of a plexus of nervous fibres.

Q Is the outer end of the principal nerve which joins the thoracic ganglion to the proper intercostal nerve:

RS Are branches of Q, which are connected by plexus to the proper intercostal nerve, nearly as the different branches of that nerve are connected to each other. Some branches, as T, seem, by their direction, to go from the proper intercostal to the great sympathetic ganglion; others seem to come from the ganglion of the sympathetic to the proper intercostal nerve.

T A B L E XXIV.

THE three first figures of this table represent the distribution, in the human subject, of the branches of the first, or olfactory pair of nerves, and of the nasal branch of the fifth pair upon the membrane of the nose. The three last figures represent the same nerves in a sheep.

FIGURE I.

- A Represents the ridge of the nose.
- B The teeth of the left side.
- C The left antrum maxillare cut open.
- D The left frontal sinus cut open.
- E The left sphenoidal sinus cut open.
- FG The ends of a bristle, passed between the membrane which lines the left side of the nose, above the upper part of the os spongiosum superius, (from which the bone has been cut off), and the branches of the first pair, or olfactory nerves. These branches join and separate again repeatedly, forming a very elegant net-work on the outside of the membrane, or between it and the bones.
- H Represents the nasal branch of the first branch of the fifth pair of nerves, ending partly in the septum narium, and partly in the membrane which lines the outer side of the nose.
- I The nasal branch of the second branch of the fifth pair of nerves.
- K Its division into branches, which are dispersed on the membrane which lines the outer side of the nose.

FIG. II.

This figure represents part of the net-work formed on the outer side of the membrane of the nose by the branches of the olfactory nerve, viewed with a magnifying glass.

FIG.

FIG. III.

This figure represents a principal part of the nasal branch of the first branch of the fifth pair, ending on the septum narium.

In justice to the dexterity and accuracy of my assistant in dissection Mr Fyfe, I think it proper to observe, that the nerves represented in this table were dissected by him, at my request, as, at the time I wanted the drawings to be made, I had not leisure myself to prosecute them with all the care which so delicate a subject requires.

In all these Three Figures, but especially in Fig. III. the nerves are represented by the engraver larger than natural.

In FIG. IV.

A Represents the point of the nose.

B The septum narium.

C Part of the cavity of the orbit.

D Part of the ethmoid bone.

E The first branch of the fifth pair of nerves.

F The proper ocular branches.

GG One of the nasal branches of the first branch of the fifth pair, terminating in the upper part of the septum narium.

FIG. V.

A The point of the nose.

B The septum narium.

D Part of the ethmoid bone.

H

- H A branch from the upper part of the olfactory, or first pair of nerves, dividing upon the septum narium into two branches *.
- I The nasal branch of the second branch of the fifth pair of nerves.
- K A branch sent outwards from I.
- LM A large branch from I, running along the bottom of the nose at the root of the septum narium.
- N A small twig from this nerve, running downwards and forwards, with the canalis incisivus, which is a large tube in all quadrupeds.

FIG. VI.

- A The point of the outer side of the nose.
- O The inner part of the side of the nose.
- K A branch of the nasal branch of the second branch of the fifth pair of nerves.
- P The division of K into branches which are spent on the inner part of the side of the nose.

TABLE

* Mr Fyfe, whom I had asked to trace the branches of the olfactory nerves in the ox or sheep, where they are much larger than in man, discovered this remarkable branch, and traced it easily, as it soon receives a firm external coat.

T A B L E XXV.

IN this table some of the branches of the nerves of the teeth and gums of a child, after birth, are delineated, after cutting off the outer part and base of the lower jaw-bone.

- A The second molaris, or backmost temporary tooth.
- B The third molaris, which is not shed, but becomes the middlemost of the five molares of the adult.
- C The back part of the trunk of the proper inferior maxillary nerve.
- D The fore part of the same nerve.
- E Several small nerves which run upwards, behind the third molaris, and are spent in the gums.
- F Two small nerves which form a plexus, and send numerous minute fibres G, into the membrane of the pulp, which fills the shell of the third molaris.
- H A few fibres from these nerves pass from the membrane of the pulp along the outside of the tooth, and are lost in the gum.

T A B L E XXVI.

THIS table represents a small but constant branch of the muscular spiral nerve of the human arm, which is connected to, and appears to terminate chiefly in, the back part of the capsular ligament of the wrist.

A The extensores carpi radiales.

B The supinator radii brevis.

CD The extensores pollicis.

E The metacarpal bone of the thumb.

F The back part of the metacarpal bones of the fingers.

G The tendons of the extensor digitorum communis, and of the indicator drawn to a side.

H The bursa mucosa of the tendons cut open at G.

I The deep branch of the radial nerve of Winslow, or muscular spiral of my Father, perforating the supinator radii brevis.

K A branch from it, which, at L, seems to grow larger, and adheres there closely to the back part of the capsular ligament of the carpus.

M Nervous filaments continued from it to the back of the metacarpus.

T A B L E

T A B L E XXVI. *

THIS table is chiefly intended to shew a plexus formed by the joining of the recurrent nerves with the superior laryngeal, and the termination of their branches in the muscles and ligaments of the larynx. The nerves of the tongue are likewise delineated.

AA A probe passed through the pharynx B, and oesophagus C.

DD A probe passed through the larynx and the trachea.

EF The dorsum and apex of the tongue.

GH The inferior maxillary gland and its duct, and the sublingual gland.

I The lingual branch of the third branch of the fifth pair of nerves.

K The lingual branch of the ninth pair and lingual artery.

L A small plexus formed by the joining of the fifth with the ninth pair.

M The lingual branch of the eighth pair.

N Part of the gland, commonly, but improperly, called thyroid.

O The inferior thyroideal artery.

P The cornu of the os hyoides.

Q The base or anterior part of the os hyoides.

R The epiglottis.

S The thyroid cartilage drawn downwards after cutting the ligaments which tie it to the os hyoides.

T The posterior and inferior corner of the thyroid cartilage, articulated with the cricoid cartilage.

U A bristle passed under the musculus crico-arytenoideus posticus.

V A bristle passed under the musculus crico-arytenoideus lateralis. Immediately above V, the musculus thyro-arytenoideus is seen obscurely.

W

W A bristle passed through the musculus arytenoideus transversus.

X The recurrent nerve.

Y The superior laryngeal nerve.

Z A plexus formed by the joining of the recurrent and superior laryngeal nerves, from which branches are sent off to each of the muscles, and also to the proper ligaments of the larynx or glottis vera.

The recurrent and superior laryngeal nerves, by being macerated at the time of drawing them, appeared much larger to the painter than they are in a recent subject.

TABLE

T A B L E XXVII.

THIS table represents, in a child, a nerve which is contained in the canalis pterygoideus of the sphenoid bone, and which joins the second branch of the fifth pair of nerves to the first ganglion of the great sympathetic nerve, and to the portio dura of the seventh pair.

ABC The nose and part of the upper lip.

D The external ear.

E The meatus auditorius externus laid open.

F The membrana tympani.

G The three semicircular canals of the ear.

H The cochlea. J The cavity of the tympanum.

IK The internal carotid artery.

L The trunk of the fifth pair of nerves.

M The root of the first branch of the fifth pair cut.

N The second branch of the fifth pair, or superior maxillary nerve.

O The root of the third branch of the fifth pair cut.

P The infra orbital branch of the second of the fifth.

Q Descending branches from the second of the fifth.

R The nasal branch of the second of the fifth, running inwards, towards the side of the nose.

S A branch reflected from the second branch of the fifth through the canalis pterygoideus.

T A branch from S, which joins with the portio dura of the seventh pair.

U A branch sent downwards from S, to terminate in V, the uppermost cervical ganglion of the great sympathetic nerve.

Qq

T A B L E

T A B L E XXVIII.

THIS table represents the human chorda tympani joining the portio dura of the seventh pair to the lingual branch of the third branch of the fifth pair *.

A The temporal bone.

B The malleus.

C The incus.

D The foramen stylo-mastoideum.

E The portio dura of the seventh pair.

F The rise of the chorda tympani.

GH Small nerves connected with the chorda tympani.

I The termination of the chorda tympani in the lingual branch of K, of the third branch of the fifth pair of nerves L.

* The bone which covered it at its rise and in its course from the cavity of the tympanum is cut off.

T A B L E XXIX.

IN this table the semicircular canals and cochlea of the human left ear are represented, with the holes in the bones for the passage of the seventh pair of nerves.

FIG. I. Represents the inner part of the left side of the base of the cranium, with the canal for the seventh pair of nerves, and the superior and posterior semicircular canals of the ear cut open, viewed from the back part of the opposite side of the head.

A The supra orbital plate of the frontal bone.

B The temporal wing of the sphenoid bone.

C The inner side of the scale of the temporal bone.

D The print made by the middle artery of the dura mater.

E The hollow under part of the occipital bone in which the left hemisphere of the cerebellum was lodged.

F The foramen magnum of the os occipitis.

G The print made by the lateral sinus.

H The hole at which the left lateral sinus and the eighth pair of nerves go out.

I The back of the posterior clinoid process of the sphenoid bone.

K The anterior clinoid process.

L The fella turcica.

M The edge of the oval hole of the sphenoid bone for the inferior maxillary nerve.

N The inner end of the os petrosum.

OO The upper and under cut sides of the canal for the seventh pair, called, improperly, meatus auditorius internus.

P

- P A bristle passed from the scala of the cochlea into the vestibule, and from the vestibule into the anterior end of the superior semicircular canal Q.
- R The posterior semicircular canal cut open.
- S The common canal formed by the joining of the semicircular canals Q and R going into the vestibule.
- T The under end of the posterior semicircular canal going into the vestibule.
- U A bristle, the two ends of which are introduced into the external inferior horizontal semicircular canal.
- V A bristle put into a passage, which is open in the skeleton at its inner end, and which is situated about a quarter of an inch farther out than the hole for the seventh pair, then passes under the superior perpendicular semicircular canal, and terminates by a blind end, within the os petrosum.
- W A bristle put into the beginning of the canal for the portio dura.
- X A bristle put into a hole in the central pillar, or modiolus of the cochlea, through which a principal branch of the portio mollis enters.
- YZ Principal holes, through which branches of the portio mollis pass to the vestibule.
- a* The hole for the aqueduct from the cochlea described by Cotunnus.
- b* The hole said by Cotunnus to transmit an aqueduct from the vestibule.

FIG. II. In this figure the bottom of the meatus auditorius internus, or canal for the seventh pair of nerves, is represented, as it appears when magnified to about six diameters.

WXYZ By these letters the same parts are pointed out as in Fig. I.

cc Represents a cribriform plate through which the other nerves of the cochlea pass.

de Shew cribriform parts through which the other nerves to the vestibule pass, and from it to the semicircular canals.

FIG.

FIG. III. Represents the os petrosum dissected, so as to shew the cochlea and femicircular canals with the passages for the nerves, viewed from the fore and outer side of the head.

- A The fella turcica.
- B The posterior clinoid process.
- C The anterior clinoid process.
- D The round hole in the sphenoid bone for the passage of the second branch of the fifth pair.
- E The oval hole for the passage of the third branch of the fifth pair.
- F The hole for the largest artery of the dura mater.
- G The future which divides the temporal bone H, from the sphenoid.
- I The inner end of the os petrosum.
- K The canal for the internal carotid artery.
- L A hole cut to shew the beginning of the canal for the carotid artery.
- MN The outer, or osseous end of the Eustachian tube laid open.
- O A bristle passed into the first turn of the posterior scala of the cochlea, which is cut open, and from it into the foramen rotundum. The diameter of the modiolus is seen here.
- PQUVWX Point out the same parts as in the Figures I. and II. X Shews the second turn of the cochlea and its apex laid open. The osseous part of the modiolus terminates in the second turn of the cochlea.
- s The cavity of the tympanum cut open.
- t A probe put from the cavity of the tympanum into the foramen ovale.
- v A probe put from the cavity of the tympanum into the foramen rotundum.

T A B L E XXX.

REPRESENTS the os petrosum dissected, after being softened, so as to shew the distribution of the portio dura and portio mollis of the seventh pair, but chiefly of the latter.

FIG. I. Represents the back view, and FIG. II. the fore view of the os petrosum, and parts of the left side.

FIG. I.

- A The inner end of the os petrosum.
- B The outer end of the os petrosum.
- C The back of the external ear.
- D The posterior end of the superior semicircular canal.
- E The superior end of the posterior semicircular canal joining with D.
- F The inferior end of the posterior semicircular canal.
- G The portio dura in the meatus auditorius internus, situated in a half sheath, formed by the portio mollis.
- H The continuation of the portio dura.
- I K The two principal parts of the portio mollis. I Ends in the cochlea, and K in the vestibule and semicircular canals.

FIG. II.

- A The upper and fore part of the cartilage of the external ear.
- B The meatus auditorius cut open its whole length.
- C The membrane of the drum.
- D The malleus.
- E The incus.
- F The head of the stapes.

G The

- G The portio dura of the seventh pair.
- H The bone which contains the fore end of the superior semicircular canal.
- I The outer and posterior part or branch of the portio mollis, running to
K the cochlea, from the membrane of the two last turns of which the
bone is separated.
- L A section of the internal carotid artery.
- M The inner end of the os petrosum cut.

FIG. III. Represents, from a similar preparation, the parts in nearly the same view as in Fig. II. and they are distinguished by the same letters.

FIG. IV. and V. Shew the portio dura and mollis, with the membrane of the cochlea, separated from the bones which covered them.

FIG. IV.

- G The portio dura turned to the outer side, so as to shew fully.
- IKL The half sheath of the portio mollis, in which the portio dura was lodged.
- I The inner side, or branch of the portio mollis, ending in M, the membrane of the cochlea, the turns and apex of which are seen distinctly.
- K The outer side, or branch of the portio mollis, which terminates in N the vestibule.
- L A thin middle portion, by which these two sides or branches are joined together.
- O A small thread that seems to be nervous, and which joins the portio dura to the outer side of the portio mollis.

In Fig. V. The same parts are represented as in Fig. IV. and distinguished by the same letters; but with this difference, that the trunk of the portio mollis is turned forwards, so as to shew the under part of IKL.

T A B L E

T A B L E XXXI

IN this table, the membrane lining the human cochlea, with the nerves from the portio mollis of the seventh pair, are represented with the utmost accuracy.

FIG. I. Represents the membrane of the cochlea, and the branch of the portio mollis sent to it, of their natural size; And

FIG. II. Represents the same parts magnified to six diameters.

A The branch of the portio mollis which is sent to the cochlea, composed of many bundles of threads.

BB Part of it lacerated by the shaking of the preparation in the liquor in which it had been preserved, for upwards of twenty years, before a drawing of it was made.

C Some of the fasciculi running upon the membrane at the first turn of the cochlea.

DEF The double edge of the membrane of the different turns of the cochlea.

G The apex of the cochlea.

H A large branch of the nerve which passes through the centre of the modiolus, and from that is continued to the apex of the cochlea where it forms a circle I.

FIG. III. Represents part of the branches of the portio mollis, distributed on the first turn of the cochlea, magnified to six diameters.

FIG.

FIG. IV. Represents some of the branches in Fig. III. magnified to about thirty diameters. In both figures, similar parts are distinguished by the same letters.

A The trunk of the branch of the portio mollis which supplies the cochlea.

BB Part of it lacerated.

K A branch of an artery crossing the nerves.

CC The fasciculi of nervous fibres disposed in a regular manner, and beginning to spread out on the membrane of the cochlea.

DD An elegant plexus which they form.

EE FF The plexus continued; but the structure and connection of parts is seen here much less distinctly, not only from the nerves dividing into much smaller parts, but that these, with the membrane, become suddenly much less white, or more pellucid.

G The edge of the membrane of the cochlea which is the most distant from the root of the lamina spiralis.

T A B L E XXXII.

FIGURE first represents the upper part of the brain and spinal marrow of a haddock, and figures second and third the top of the spinal marrow of a cod, with the nerves issuing from these, and certain spheroidal bodies loosely connected to the brain, but closely to the nerves.

FIG. I.

A The fore part of the upper jaw.

BB Two nostrils on each side, with probes in them.

CC The eye balls.

DE Lobes or hemispheres of the brain.

F The hemispheres of the cerebellum.

Numerous spheroidal bodies are slightly connected to the brain by viscid matter between it and the cranium, others are more closely attached to the dura mater.

G The spine and spinal marrow cut transversely.

I The olfactory nerves.

K Two spherical cineritious bodies with which the olfactory nerves are intimately conjoined.

LL The branches of the olfactory nerves ending in the bottom of the nose.

MM A pair of large nerves resembling the fifth pair in man.

OO Small branches are here detached towards the back part of the nose, resembling the nasal branches of the fifth pair in man.

PP Anterior maxillary branches of the fifth pair.

NN The optic nerves entering the eye balls.

Q Spheroidal bodies attached slightly to the medulla oblongata and top of the spinal marrow.

R The

EXPLANATION OF THE TABLES. 163

R The back part of the spine, with several pairs of nerves issuing from it, covered by spheroidal bodies, firmly connected to the nerves and to each other.

HH The pectoral fins, on one of which these nerves are seen dividing into small branches.

SS Nerves, running lengthwise on the sides of the body, to which no spheroidal bodies are attached.

FIG. II. Represents, in a cod, the upper part of the spinal marrow, of the natural size. And Fig. III. represents part of Fig. II. magnified.

A The spinal marrow.

B Spheroidal bodies loosely attached to the spinal marrow.

C In Fig. II. Spheroidal bodies, covering and closely connected to the nerves and to each other.

Within the spheroidal bodies, which are transparent, white serpentine bodies are seen as in Fig. III.

TABLE

T A B L E XXXIII.

THIS table represents the nerves of the fin of a haddock, with spheroidal bodies connected to them, magnified to six diameters.

FIG. I.

AB Two nerves which join and separate again, or form a plexus, which is covered by spheroidal bodies, adhering closely to it.

B About the middle of the fin these spheroidal bodies are not contiguous to each other, but between them the pure nerve is seen.

C Near the extremity of the fin, where the nerves are subdivided into small parts, the spheroidal bodies are wanting.

FIG. II. Shews the spheroidal bodies separated from the nerve and from each other, and magnified to six diameters.

They consist of a tough transparent membrane or skin, containing a transparent viscid liquor, in the centre of which one or two white, or opaque, serpentine bodies are lodged. These serpentine bodies are seen very distinctly, not only when the nerve is recent, but after drying it.

FIG. III. Represents the spheroidal vesicles, loosened a little from each other by dissection, and magnified to six diameters.

T A B L E

T A B L E XXXIV.

FIGURE first of this table represents the spinal marrow and nerves in the tail of a small haddock, dissected, and magnified to four diameters.

FIG. II. Shews the natural size of the tail.

FIG. I.

A The upper, and B the under part of the haddock.

CCC The Bodies of the vertebrae.

DD The spinal marrow, with the spinal nerves issuing from it.

These nerves, as they proceed, form plexuses GG, which are covered by spheroidal bodies that adhere firmly to the nerves, and to each other. In the fin of the tail the spheroidal bodies gradually become less numerous, then are seen single, or at a distance from each other, with the nerve appearing bare between them, as at HH, where the nerves are supported on pins. At last, near the edges of the fin of the tail, where the nerves are divided into small parts, the spheroidal bodies are not found.

T t

T A B L E

T A B L E XXXV.

THIS table shews the appearance of the branches of the portio mollis dispersed on the human cochlea, viewed in the sun-shine with a double microscope, which enlarges the diameter 146 times.

A A nerve entering the cochlea.

BB Serpentine, or convoluted fibres, which seem to compose the fibres of which the nervous plexus formed here consists.

C The continuation of the plexus which, at this place, becomes very transparent.

D The threads of the plexus seem, at this place, spread out uniformly.

T A B L E

T A B L E XXXVI.

FIGURES first, second, and third, shew the appearance of the retina of the human eye, when viewed in the sunshine with the microscope.

In Fig. I. The diameter is magnified about seven times.

a Is the retina. *b* Is an artery.

In Fig. II. The diameter is increased about 60 times.

In Fig. III. The diameter is increased 146 times.

FIG. IV. Shews the appearance of the membrane; and Fig. V. Of the substance of the crystalline lens, when viewed with a microscope, which increases the diameter 146 times.

FIG. VI. Represents part of the membrane of the nose, viewed with the same microscope.

T A B L E

T A B L E XXXVII.

FIG. I. The dura mater.

FIG. II. The pia mater.

FIG. III. A The cortex B Medulla cerebri.

FIG. IV. and V. Portions of nerves.

FIG. VI. Part of a ganglion of a nerve.

FIG. VII. and VIII. Portions of muscles.

FIG. IX. Part of the tendon of a muscle.

All viewed with a double microscope, which increases their diameter
146 times.

T A B L E

T A B L E XXXVIII.

THE three figures in this table represent the appearance of the muscular fibres, and nerves entering them, when viewed, in sun-shine, with a double microscope which increases their diameter 146 times.

A The outlines of the muscular fibres.

B Nerves running to the muscles.

C Nerves fixed to, and seeming to form the muscular fibres.

T A B L E XXXIX.

FIG. I. Part of an artery.

FIG. II. Part of a nerve.

FIG. III. Part of the lungs.

FIG. IV. Part of the pleura.

FIG. V. Part of a bone.

FIG. VI. Part of the nail.

Viewed in sun-shine with a microscope which increases the diameter 146 times.

U u

T A B L E

T A B L E XL.

IN this table, the appearance of a perpendicular section of the papillae of the skin of the finger after the cuticula was detached by putrefaction, is represented magnified to 146 diameters.

FIG. I.

A Represents the section of the papilla which, I have found, is subdivided by irregular partitions.

At B, on which the light of the sun is thrown by reflexion, the whole papilla and subjacent part of the skin seem to be composed of serpentine fibres.

FIG. II.

A Represents exactly the appearance of the external surface of one of the cutaneous papillae.

At B, on which the light of the sun is thrown by reflexion, the surface seems to be covered with a web of serpentine fibres.

T A B L E XLI.

THIS table represents the appearance of the parts which compose the common teguments, illuminated by sunshine, and viewed through a microscope which increases the diameter 146 times.

The Figures I. II. III. IV. represent the human hairs of the head with the bulbs in which they are rooted.

AA Their bulbs.

BBBBBB Arteries and veins of their bulbs.

CCC The hairs.

D In Fig. IV. One hair splitting near the point into two fibres.

All the above parts seem to have numerous serpentine fibres in their composition.

FIG. V. Is a rude sketch of the appearance of the skin, cuticula, and fibres which connect them together.

A The cuticula.

B The cutis vera.

CCC The fibres which connect the cuticula to the cutis vera.

Serpentine fibres seem to enter into their composition.

FIG. VI. Is a very accurate drawing of the size and shape of the follicles which, I have found, contain the fat in all parts of the body.

These viewed in a clear light, especially in sunshine, seem to be covered with a net-work of serpentine fibres.

T A B L E

T A B L E XLII.

THIS table shews the appearance of a mite, viewed in the sun-shine with a double microscope, which magnifies the diameter 146 times.

The whole body and limbs seem to be composed of convoluted fibres.

T A B L E XLIII.

THIS table represents the appearance of some of the parts of vegetables viewed with the microscope.

FIG. I. Represents, of its real size, a transverse section of a branch of lilac.

FIG. II. Represents the same branch, viewed through a magnifying glass which increases its diameter about six times.

FIG. III. Shews the appearance of the same branch viewed in sun-shine, with a double microscope, which increases the diameter 146 times.

A The pith lodged in cells.

B Air vessels in the wood.

C The bark.

All these parts appear to have serpentine fibres in their composition when viewed in sun-shine.

FIG. IV. Shews the appearance of fir dried; and Fig. V. and VI. shew the appearance of thin slices from the recent leaves of myrtle and geranium, seen through a microscope, which increases the diameter 146 times.

Numerous serpentine fibres seem to enter into the texture of the wood and of the leaves.

T A B L E

T A B L E XLIV.

THE several figures in this table represent an appearance of serpentine fibres in the metals, semimetals, stone, gum, solid oily bodies, salt, when viewed in sunshine with a microscope which magnifies the diameter 146 times.

FIG. I. II. III. Represent the appearance of the surface of gold, silver, and tin, cooled, after being melted.

FIG. IV. V. VI. Represent gold, silver, and iron, polished.

FIG. VII. The point of a new lancet.

FIG. VIII. A bit of gold leaf.

FIG. IX. A bit of flint.

FIG. X. Gum Arabic.

FIG. XI. XII. Tallow and spermaceti.

FIG. XIII. XIV. Crystals of sea salt.

T A B L E XLV.

IN this table the appearance is represented of different metals, viewed with a microscope which enlarges the diameter 146 times.

FIG. I. Represents gold that has been polished.

FIG. II. Represents leaf-gold, in which serpentine looking fibres appear, not larger nor more irregular than in pieces of metal, melted and cooled without being polished, or polished after they were cooled.

FIG. III. Tin. And

FIG. IV. Lead, both of which had been melted and afterwards cooled.

T A B L E

T A B L E XLVI.

THIS table represents the appearance of very numerous vessels, injected in cicatrices, which supplied the place of portions of the skin of a pig which had been cut out.

FIG. I. Represents the injected vessels of a cicatrice of the skin, of their natural size.

FIG. II. Represents the same magnified.

In FIG. III. A Represents the injected vessels of a cicatrice of the skin of the head.

B Represents the injected vessels of a new formed membrane, connected with the pericranium, and which filled up a hole that had been cut in the scull with the trepan.

T A B L E

T A B L E XLVII.

FIGURES first and second of this table represent vessels injected from the aorta, in a portion of the skin of the abdomen of a pig, which, before the injection was made, had been completely detached from the neighbouring parts, by incisions made at different times.

FIG. I. Represents the parts of their natural size.

AA A longitudinal cicatrice, which rejoined the parts of the skin which had been divided by an incision.

B, B, B, B, B, B, B, B, Cicatrices filling holes made by the needles used in sewing up the incision.

CD Vessels on both sides of the cicatrice or incision.

AA filled by injection, although the injection was thrown into the trunks of the vessels on one side only of the cicatrice.

FIG. II. Represents the vessels in the portions **CD**, as they appear viewed with a magnifying glass. Some of them can be seen passing across the cicatrice **AA**.

FIG. III. IV. Represent vessels injected in a new formed membrane which connected the intestine ilium of a pig to the peritoneum lining the abdominal muscles.

Fig. III. Represents the parts of their natural size; and **Fig. IV.** represents a portion of the same magnified.

A A section of the skin and muscles of the abdomen.

B The inner side of the muscles lined with the peritoneum.

D The surface of the ilium, connected to the peritoneum by a very vascular new formed membrane **C**.



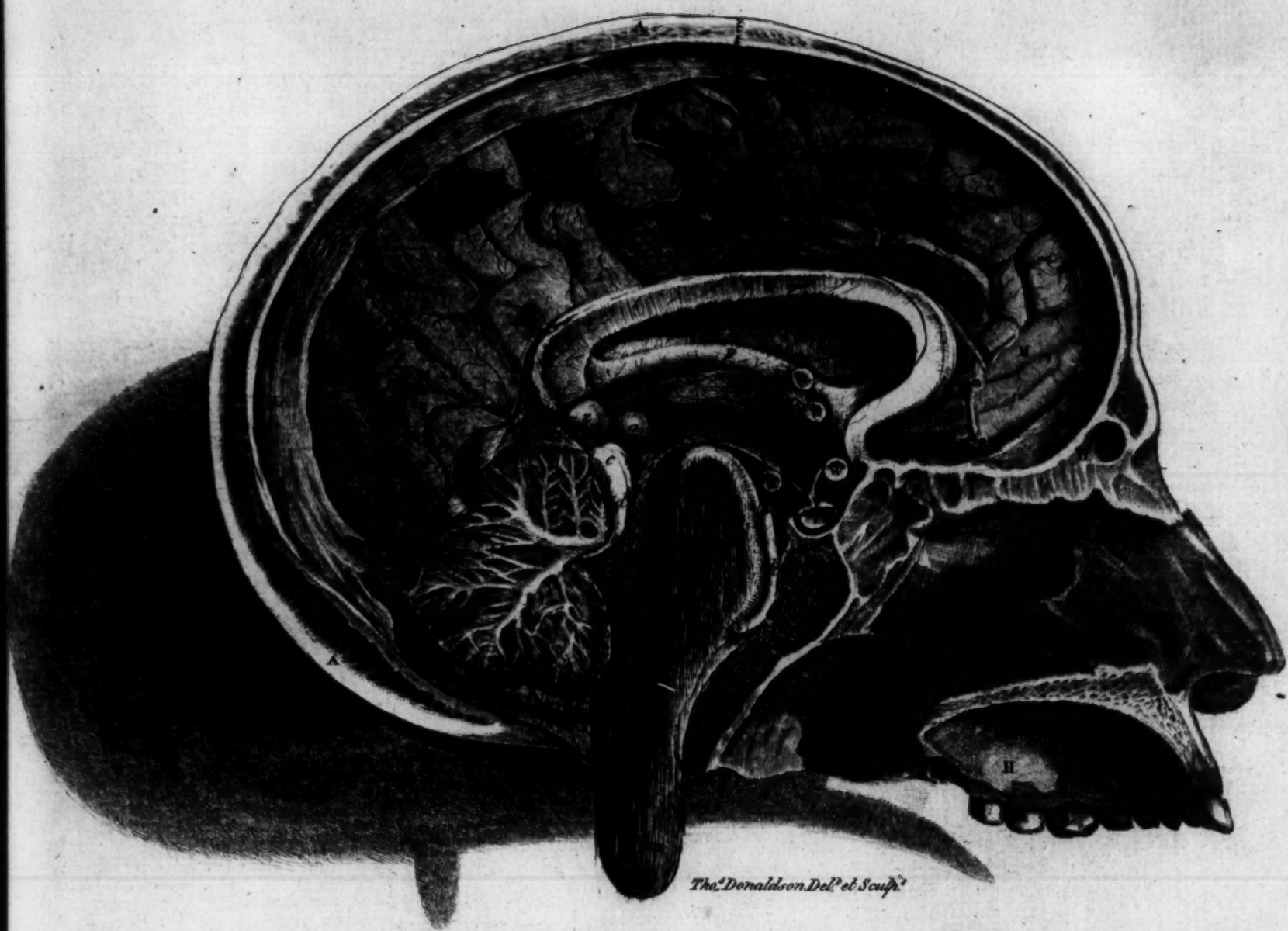
F I N I S.

TAB. I.





TAB. II



Thos. Donaldson Del. et Sculp.

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41



TAB. III.

Fig. 3.



Fig. 1.

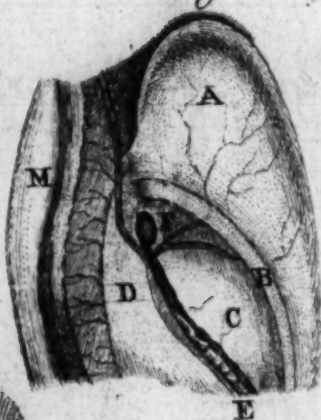


Fig. 2.



Fig. 4.



Fig. 5.



TAB. II.



TAB. IV.

Fig. 1.

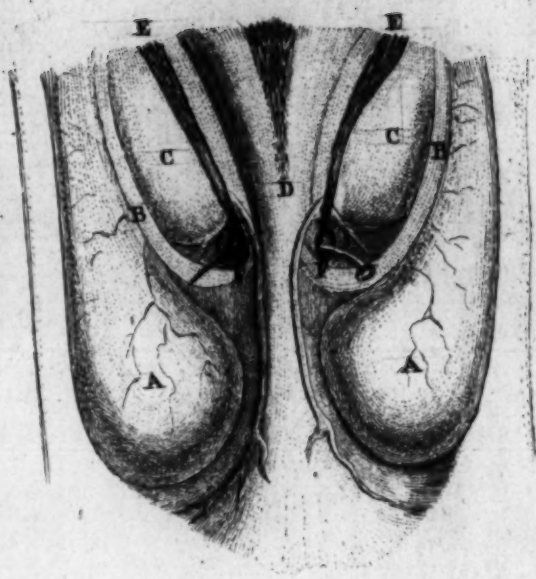


Fig. 2.

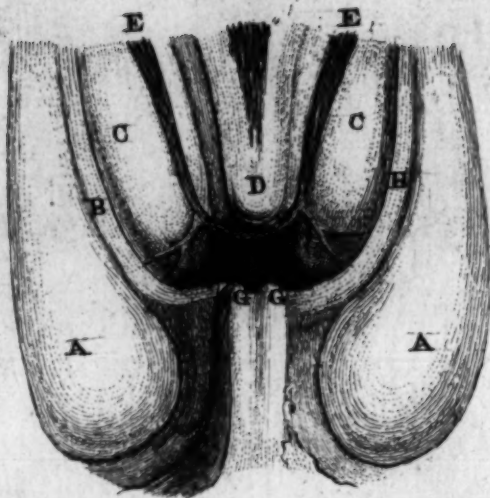
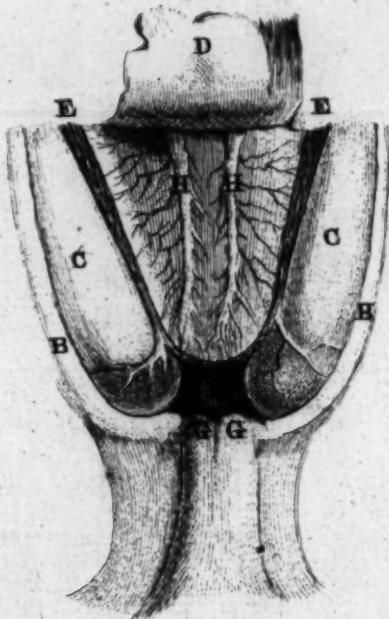


Fig. 3.

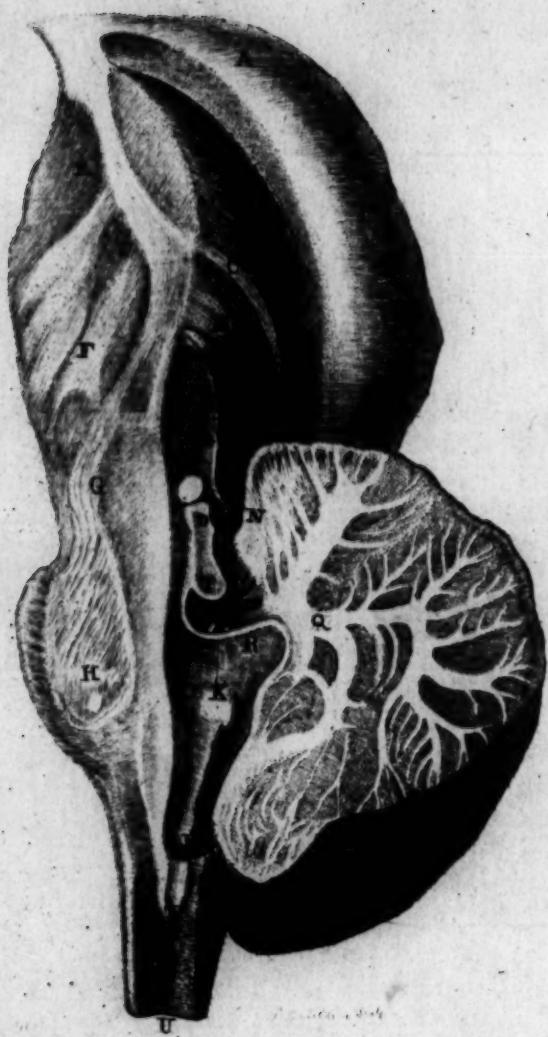


141





TAB. VI.





TAB. VII

Fig. 1.

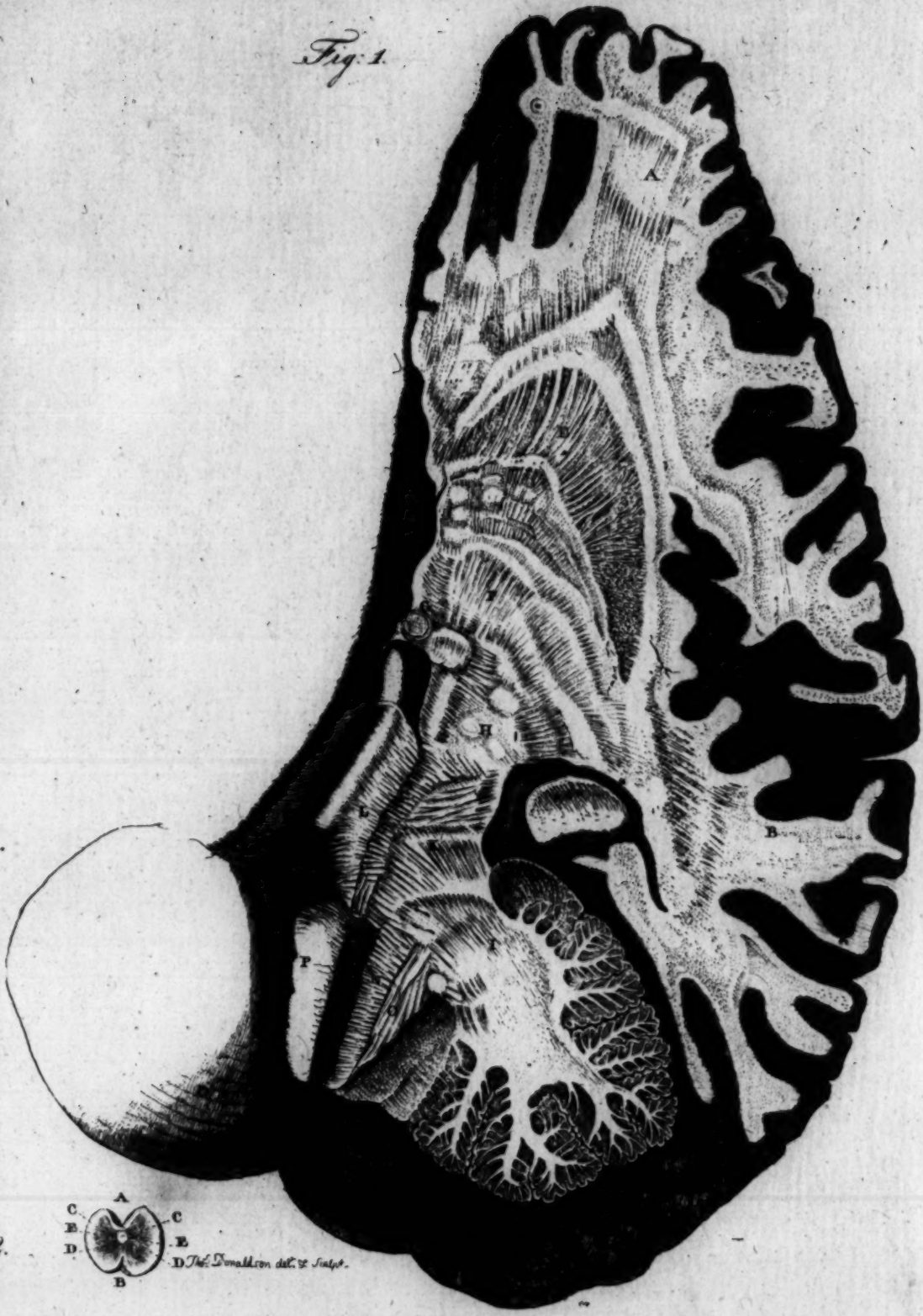


Fig. 2.



D. Tab. Donalson del. et sculp.

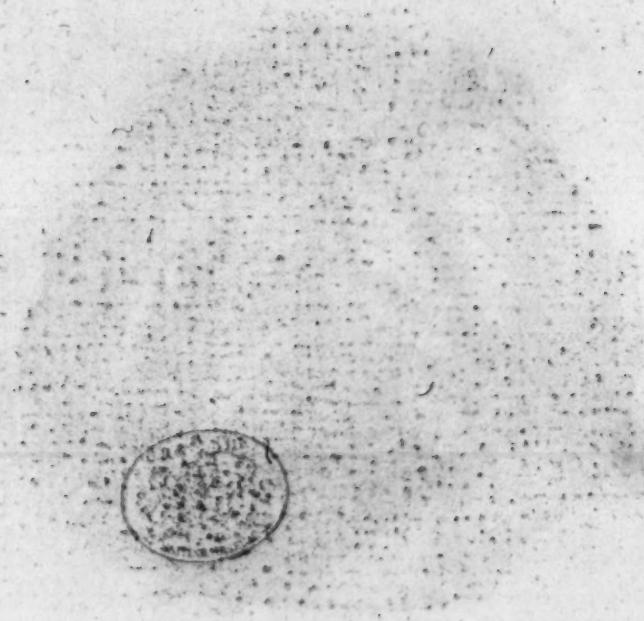
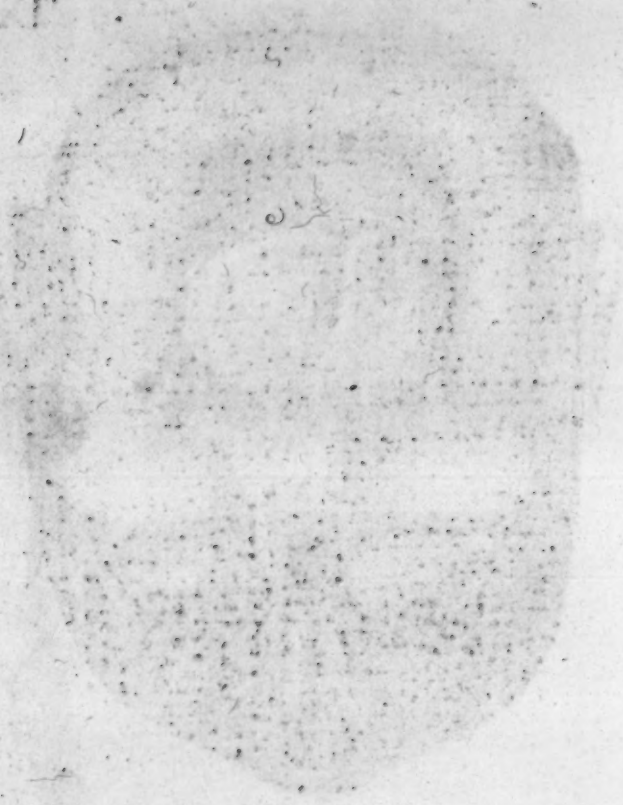


Fig. 1.

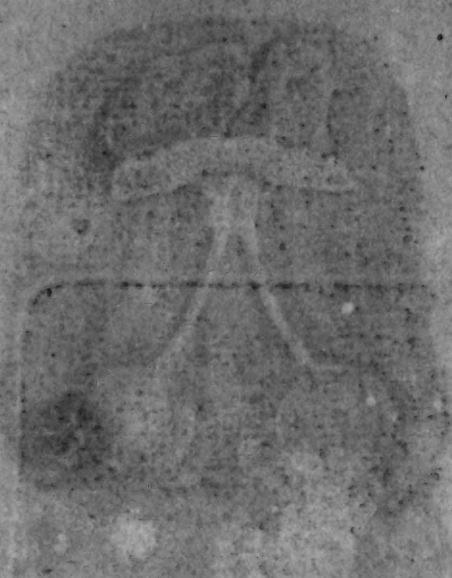
TAB. VIII

Fig. 2.



Fig. 3.



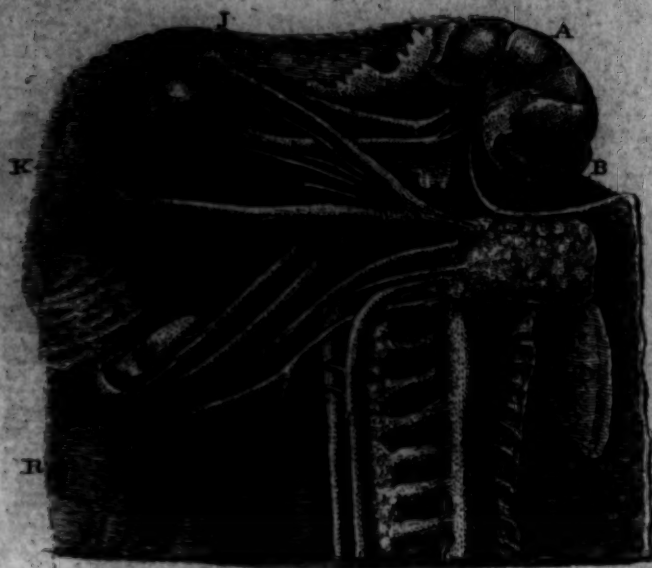


III



TAB. VIII. ✕

Fig. 1.



A. Fyfe del.

XV F

Fig. 2.



The Donalson Sculp.

Fig. 3.



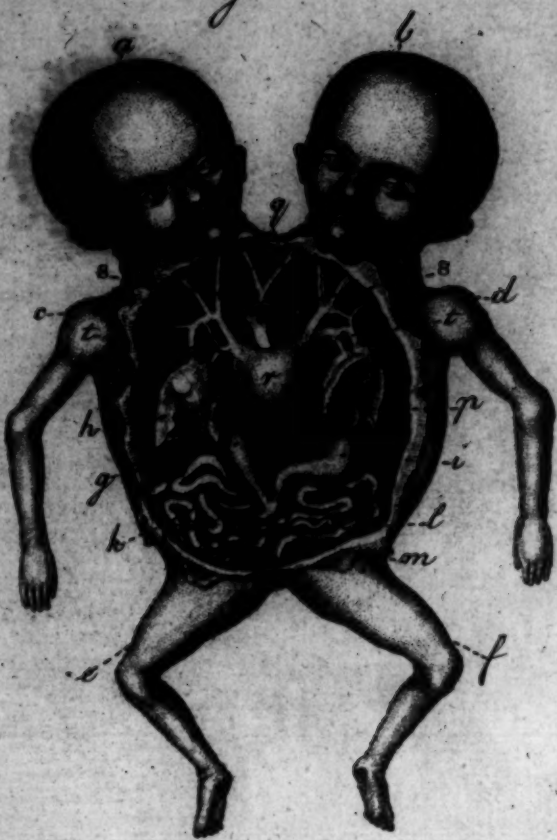
A. Fyfe del.

The Donalson Sculp.

PLATE III. A. T.

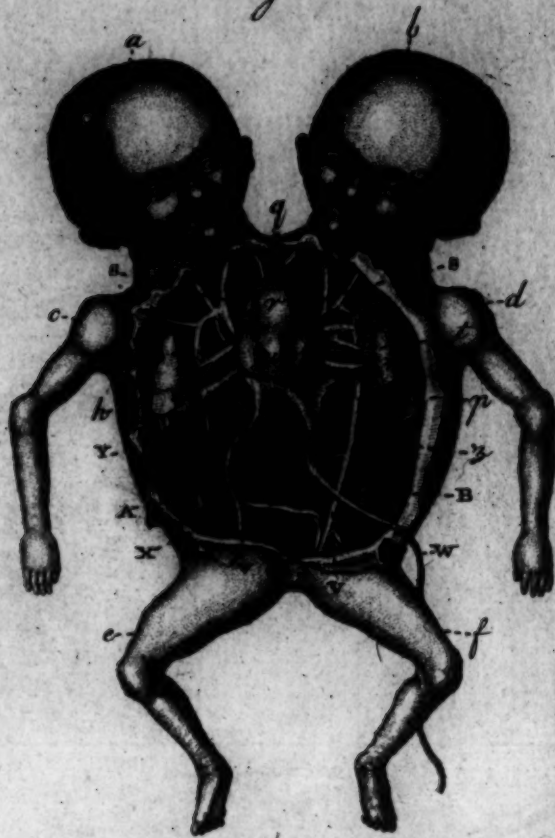


Fig. 1.



A. Fyfe del.

Fig. 2.



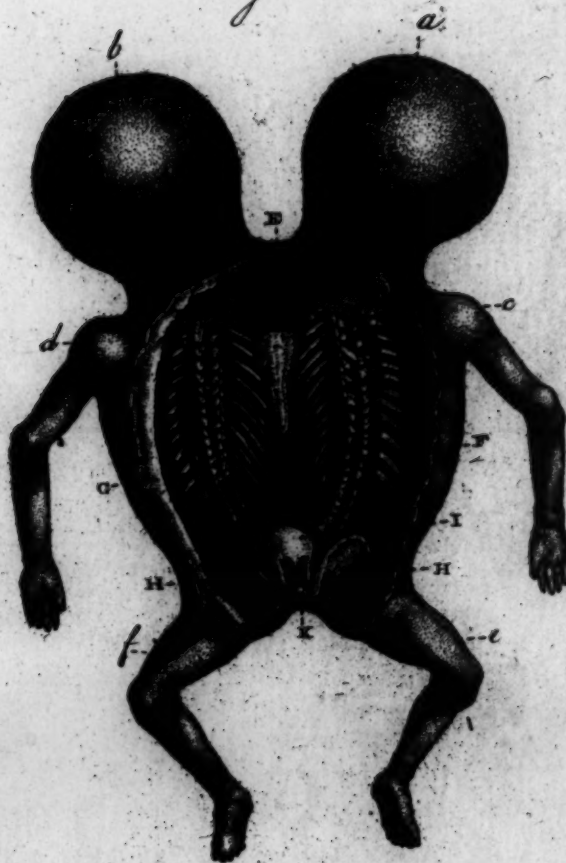
The Donalson Sculp.

Fig. 3.



A. Fyfe del.

Fig. 4.



The Donalson Sculp.

For 18



TAB. IX

Fig. 1.

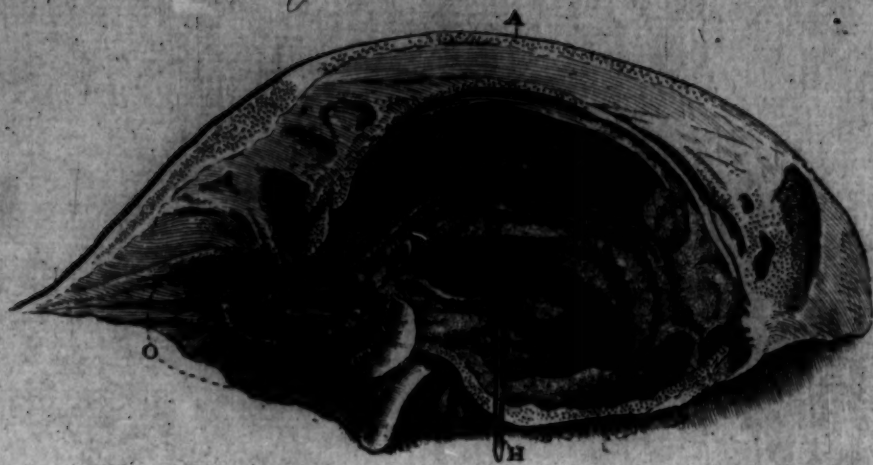


Fig. 2.

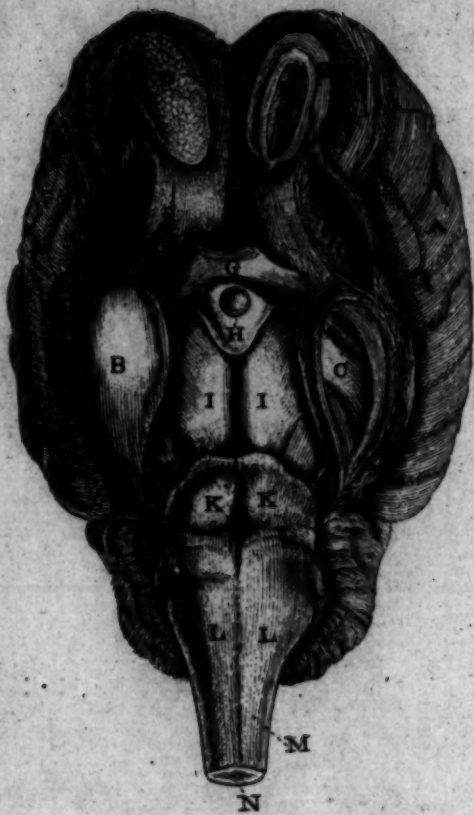


Fig. 3.



Fig. 8.



A. Lyfe del.

Fig. 7.



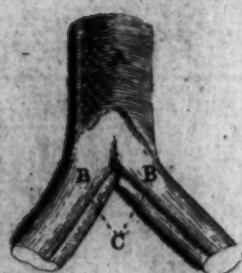
Fig. 6.



Fig. 5.



Fig. 4.



G. Cameron sculpt.

Fig. 9.



A. Lyfe del.

Thos. Donaldson sculpt.



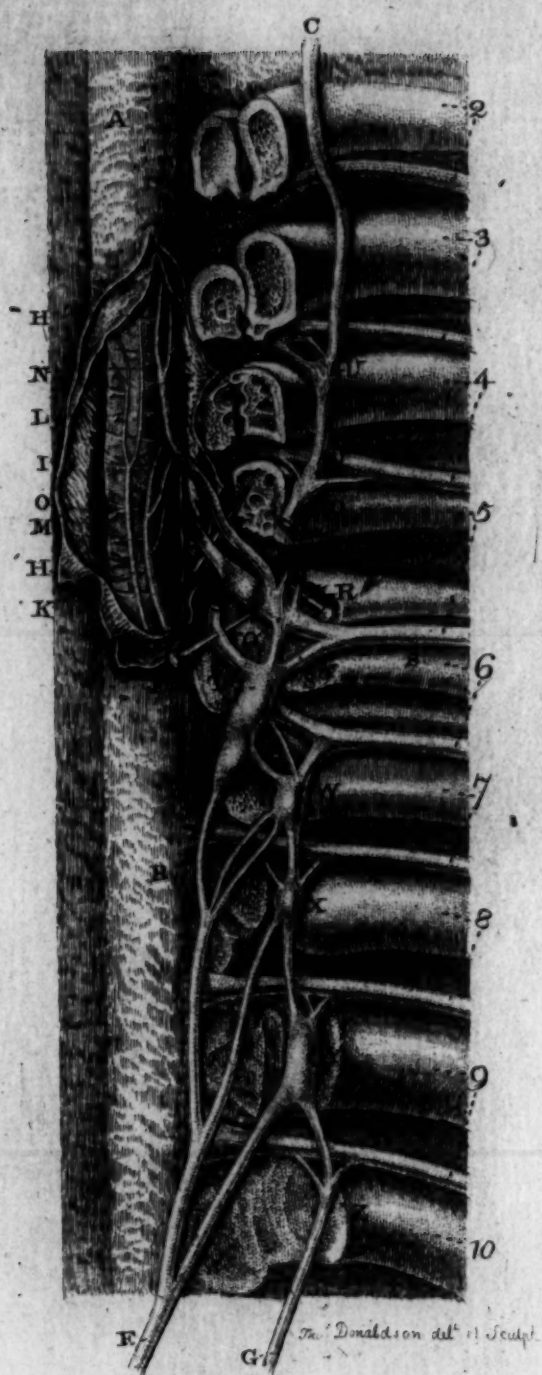


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ANATOMY



TAB. XI



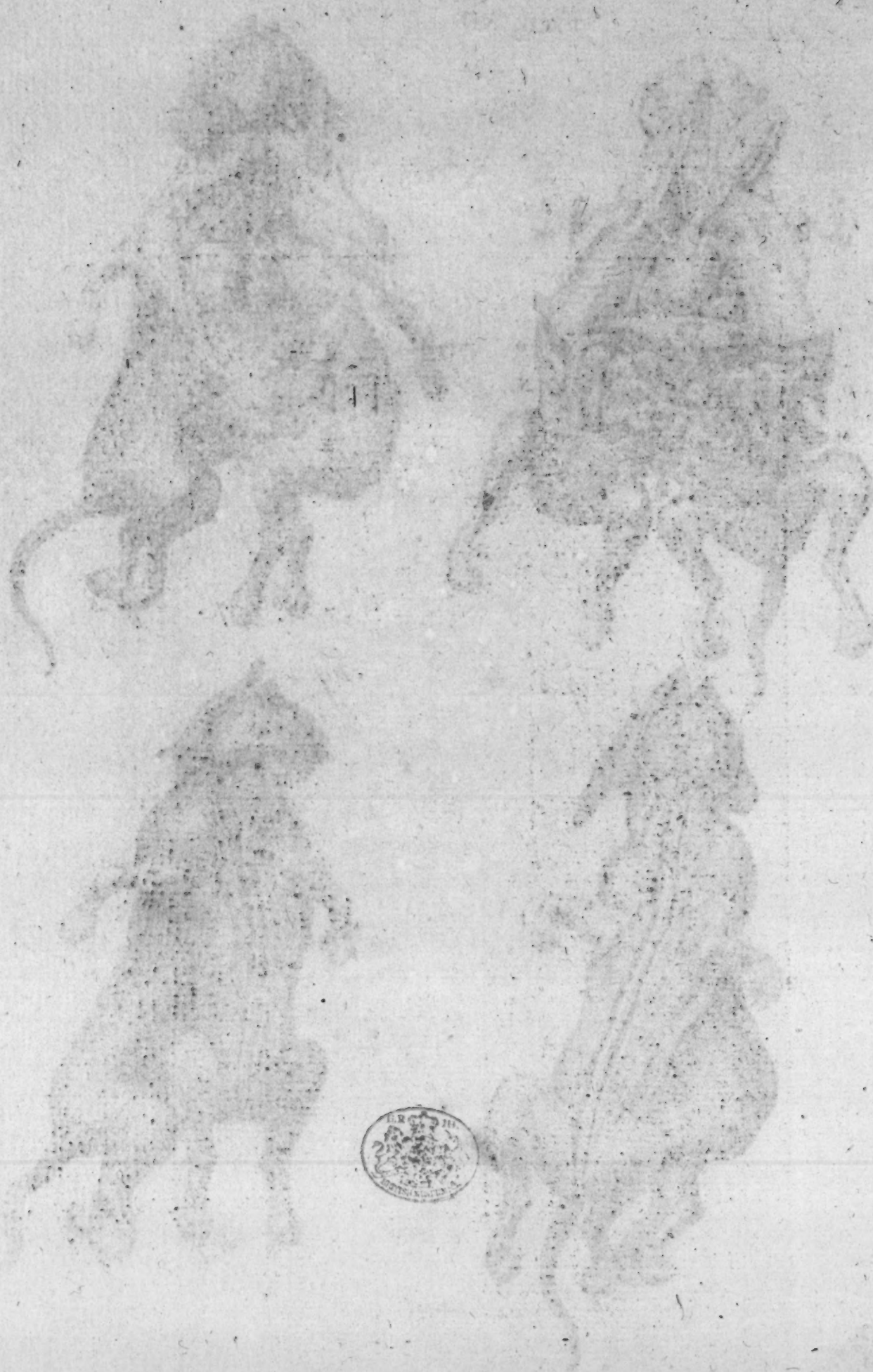


Fig. 1.

TAB. XII

Fig. 2.



Fig. 3.

Fig. 4.



W. D. Smith del. & sculp.



TAB. XIV

Fig. 1.

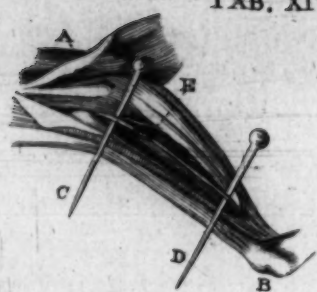
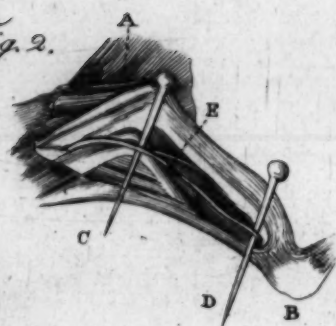
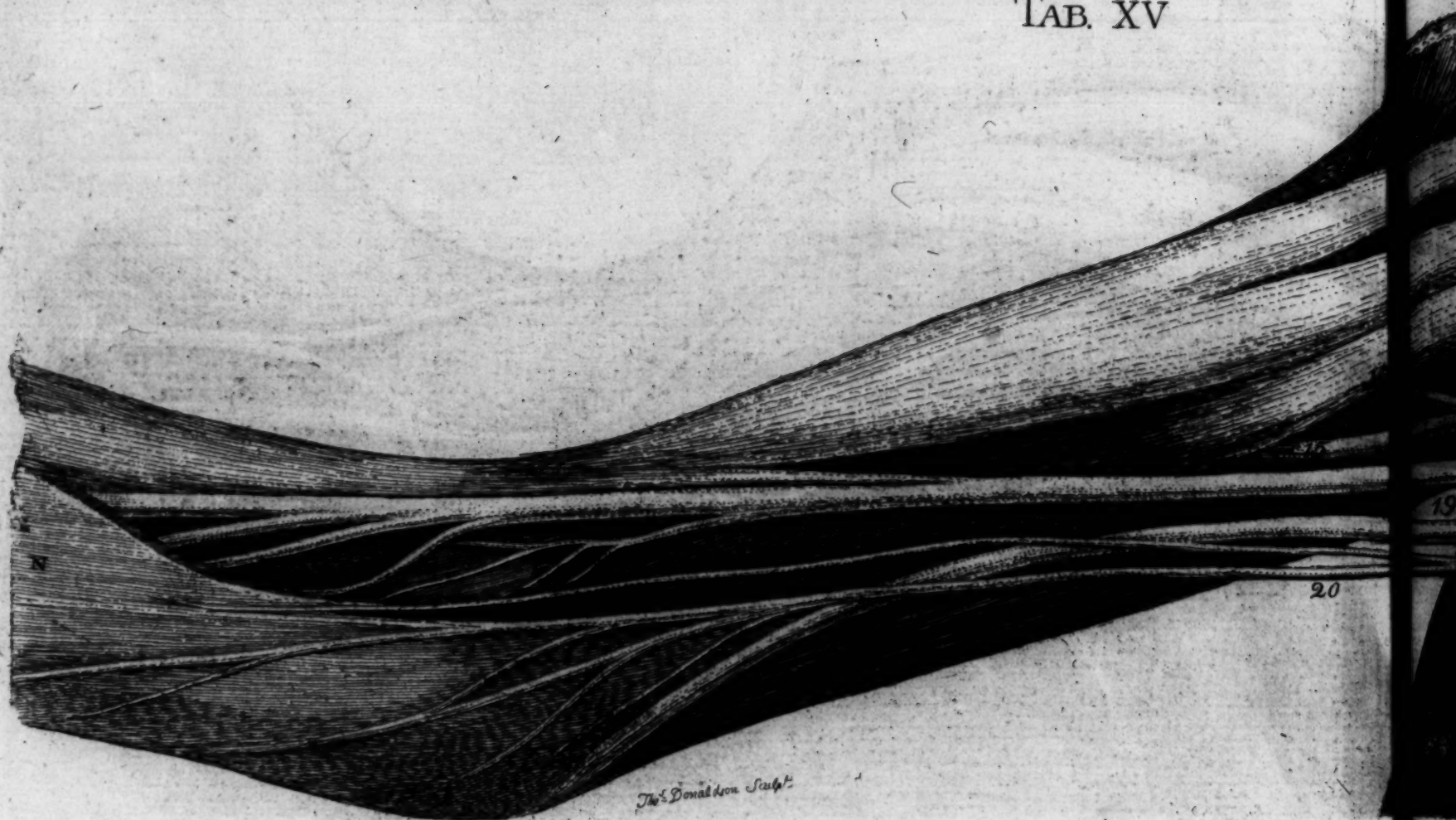


Fig. 2.





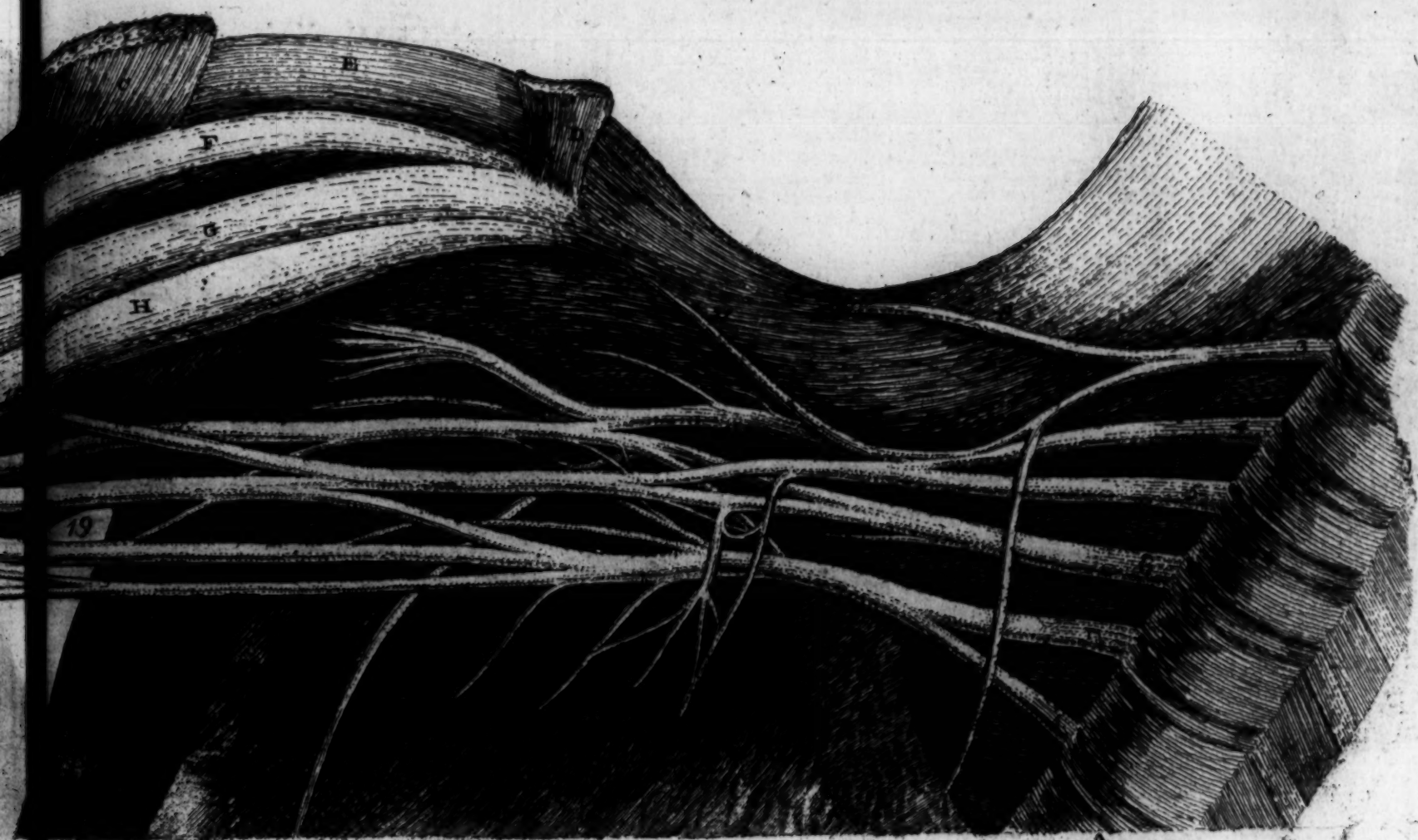
TAB. XV



J. Donaldson Sculp.

20

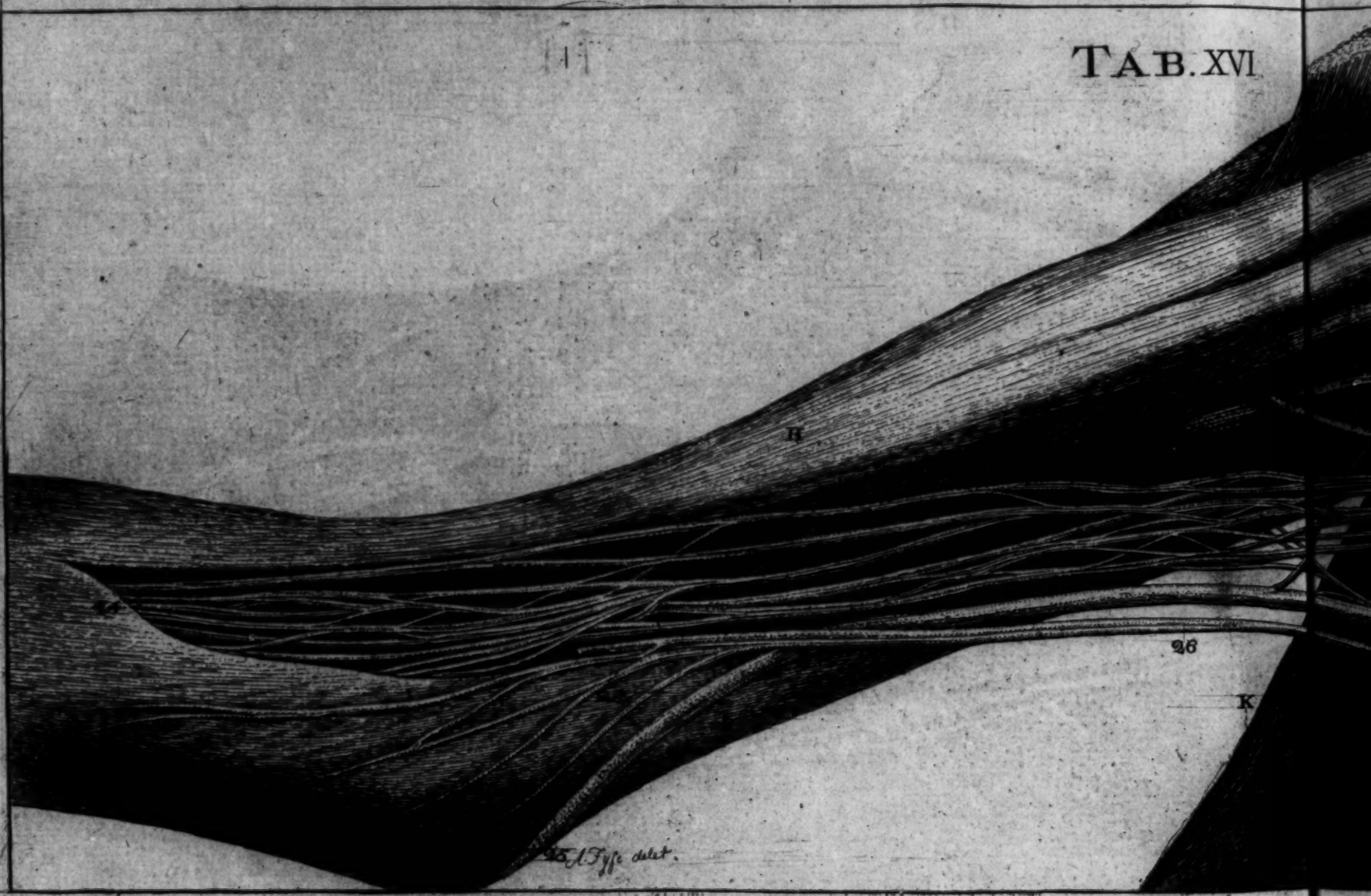
19

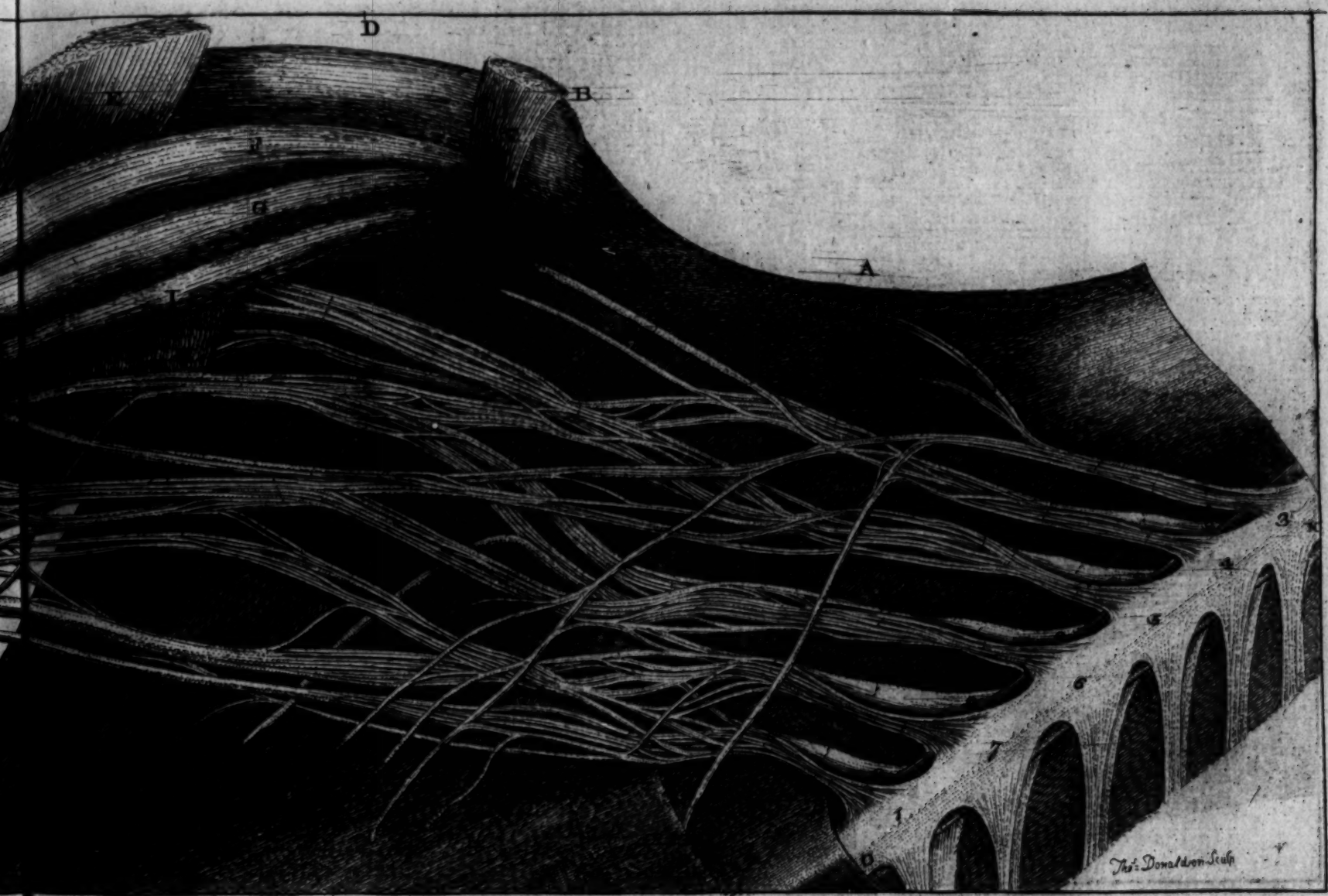


141



TAB. XVI



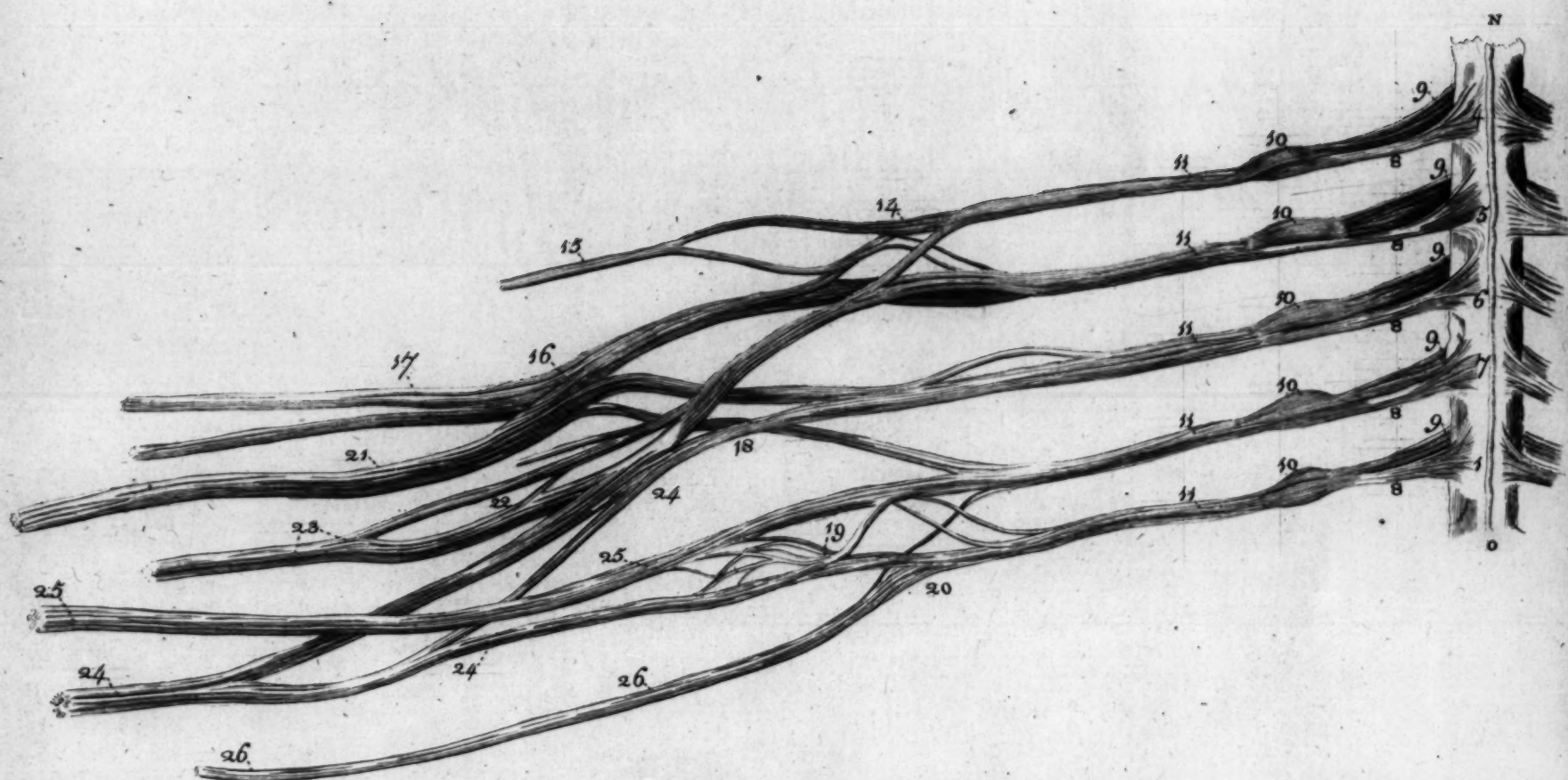


sculp

144 ADX 047



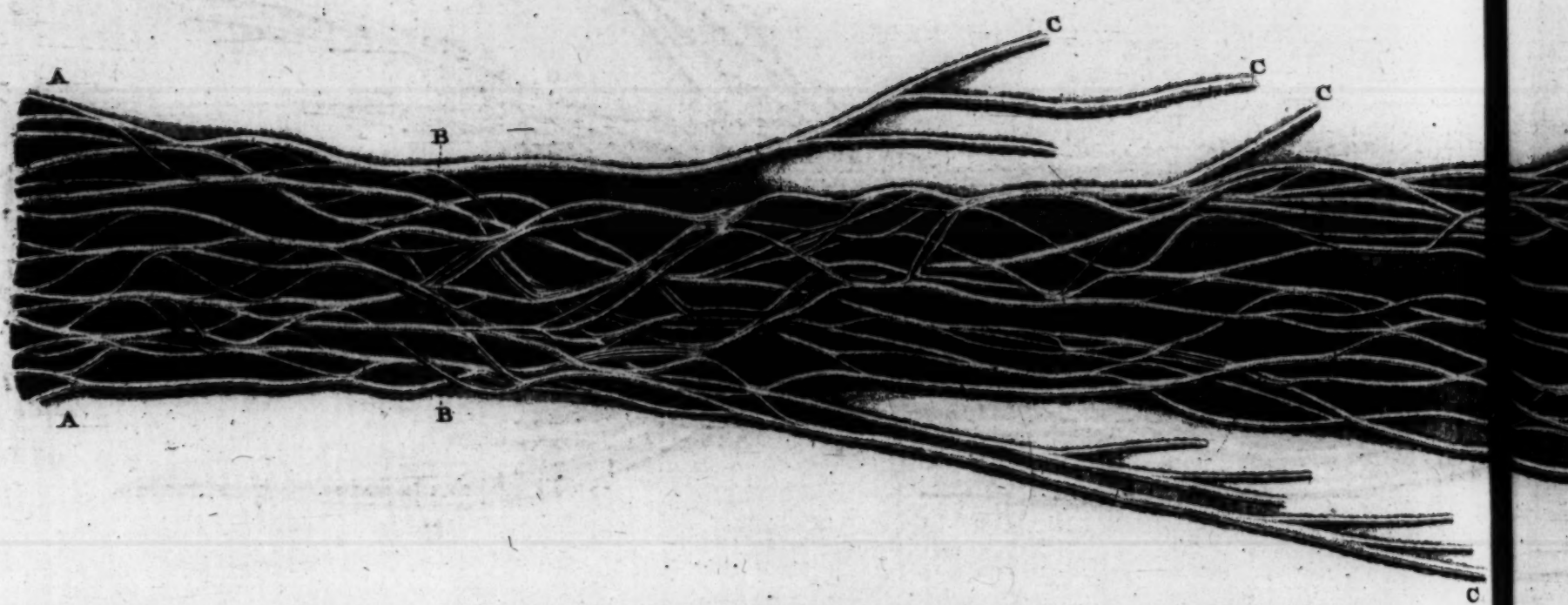
TAB. XVII



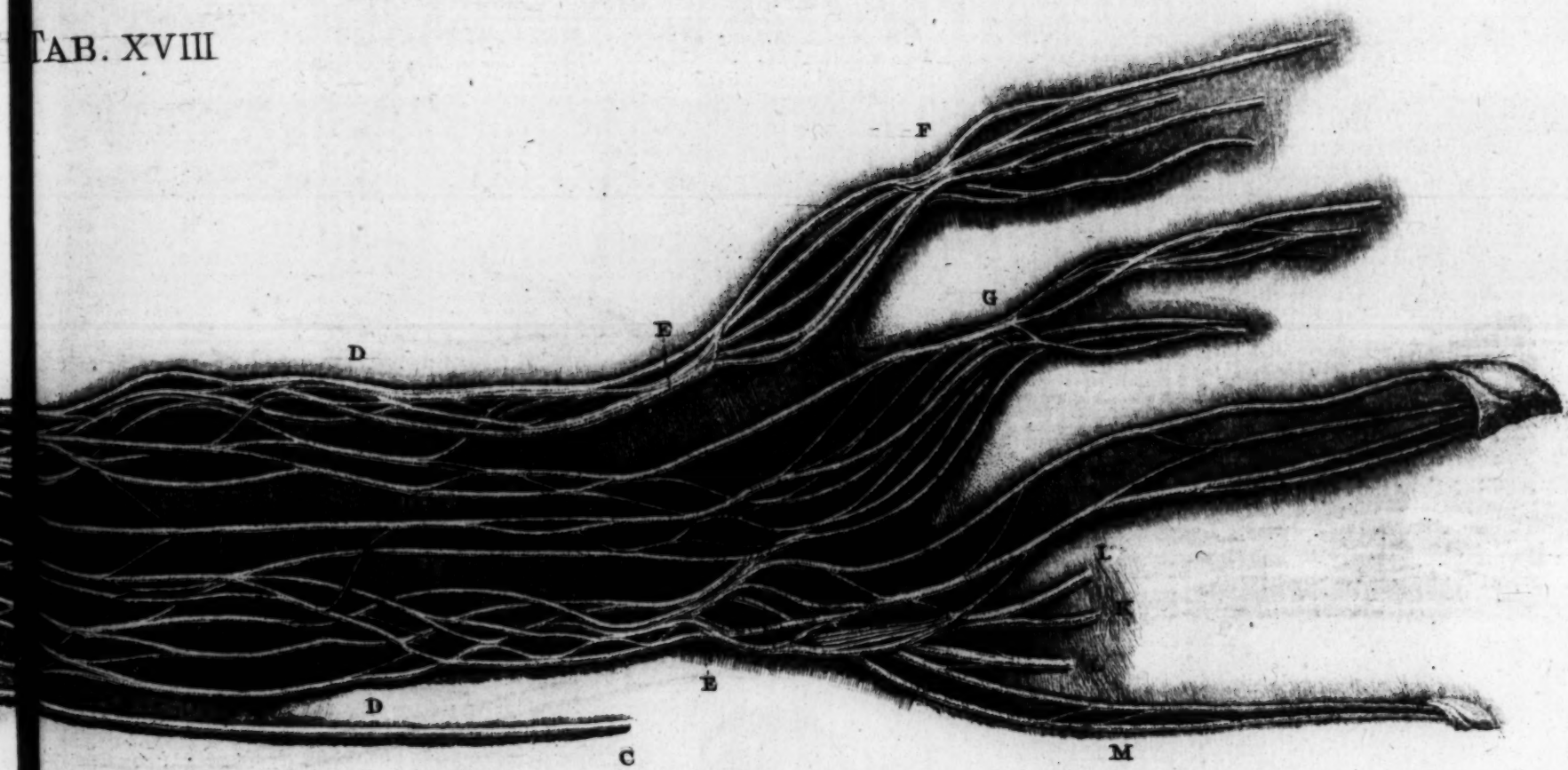
Pyfe del^t

G. Cameron sculp





TAB. XVIII





TAB. XIX

Fig. 1.

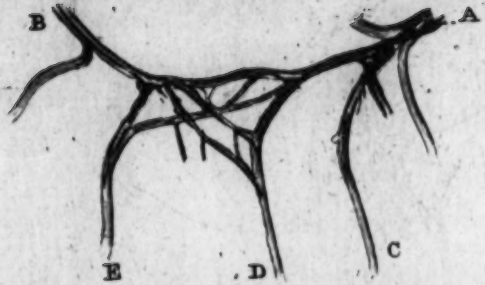
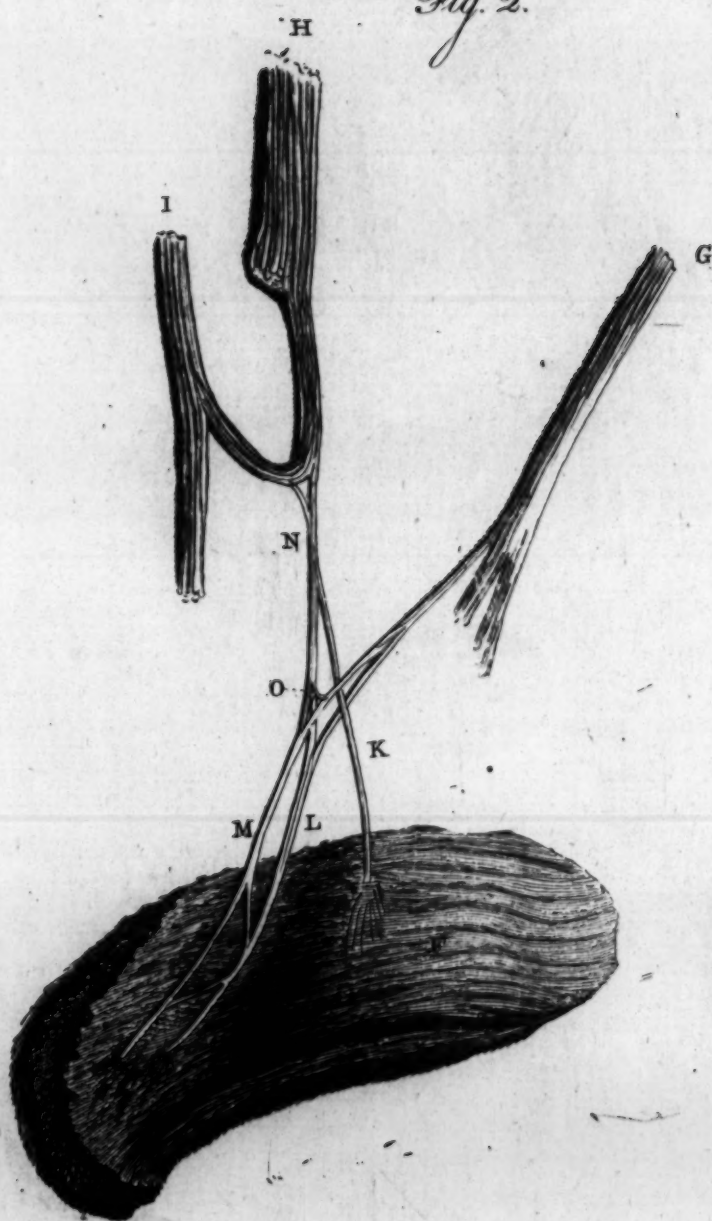


Fig. 2.



A. Fyfe del^t

G. Cameron sculpt^r



TAB XX

Fig. 1.



Fig. 3.



Fig. 2.

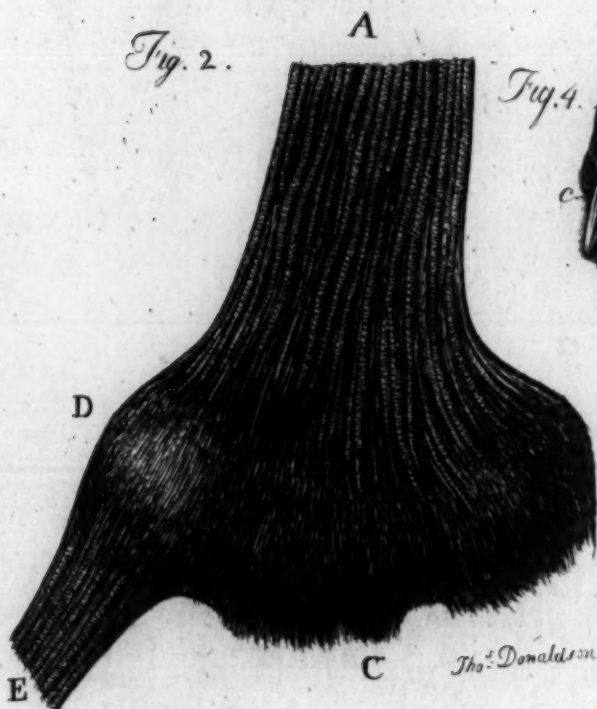


Fig. 4.

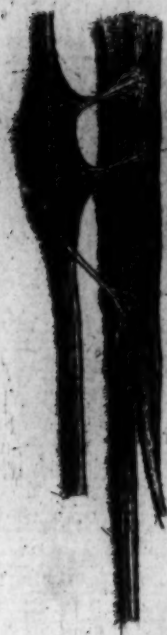


Tho. Donaldson Sculp.



TAB. XXI

F.1



F.2



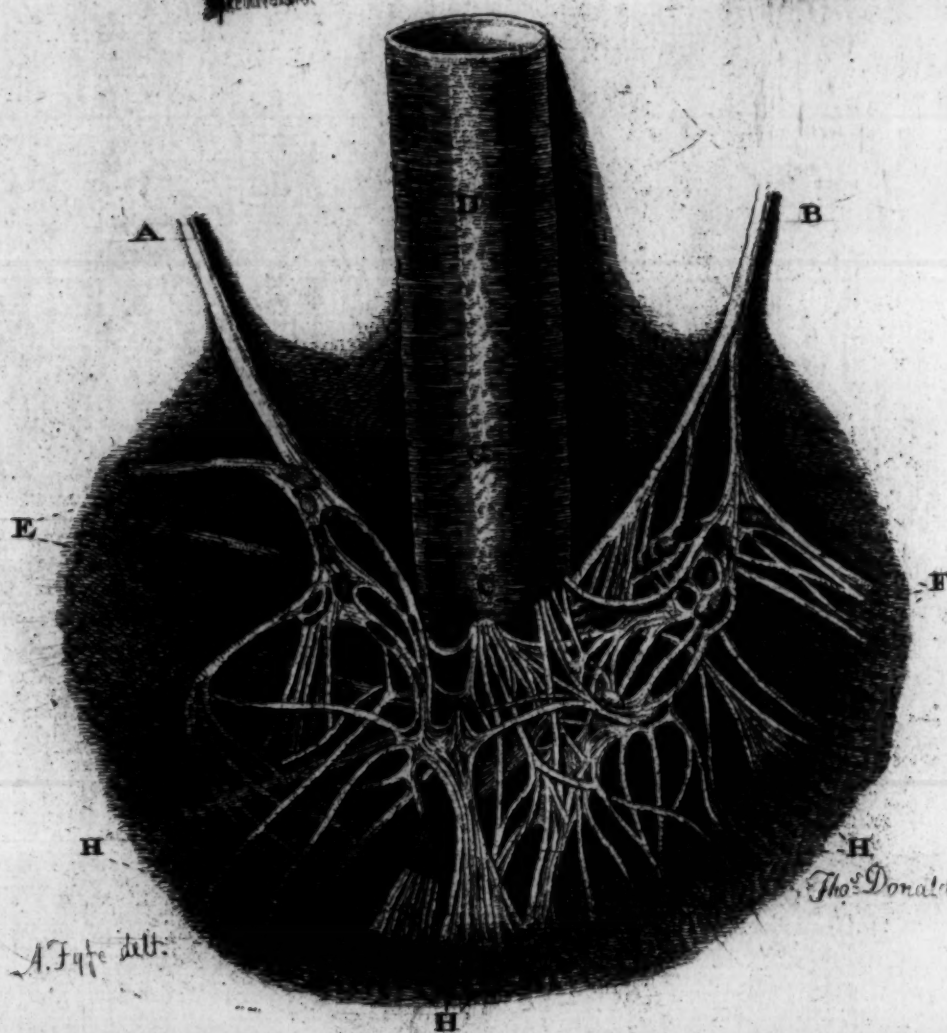
F.4



F.3



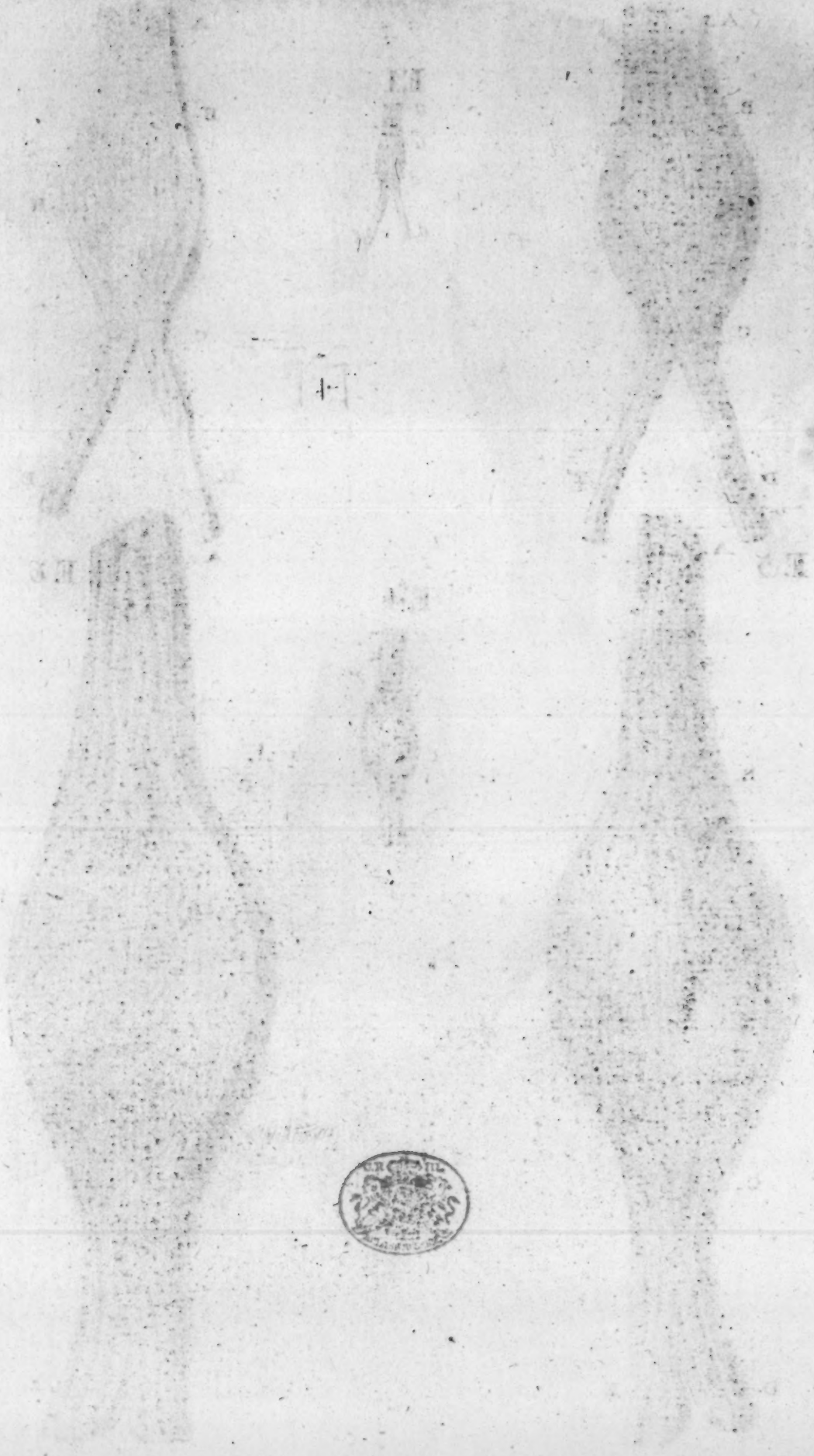
F.5



A. F. 17c delt.

Tho. Donaldson Sculp.

PLATE XXII



TAB. XXII

F2



F1



F3



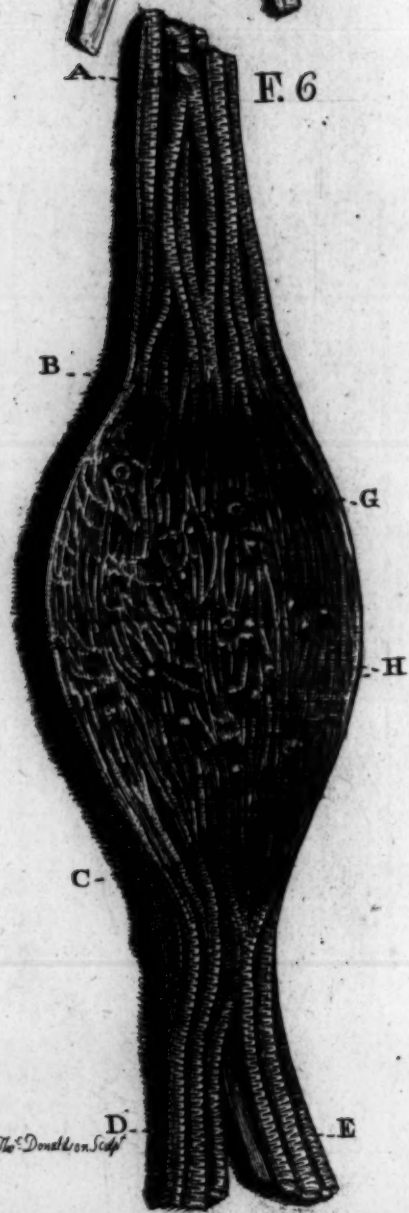
F5



F4

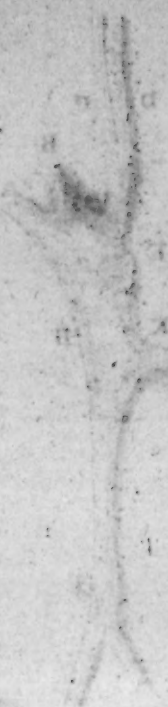


F6

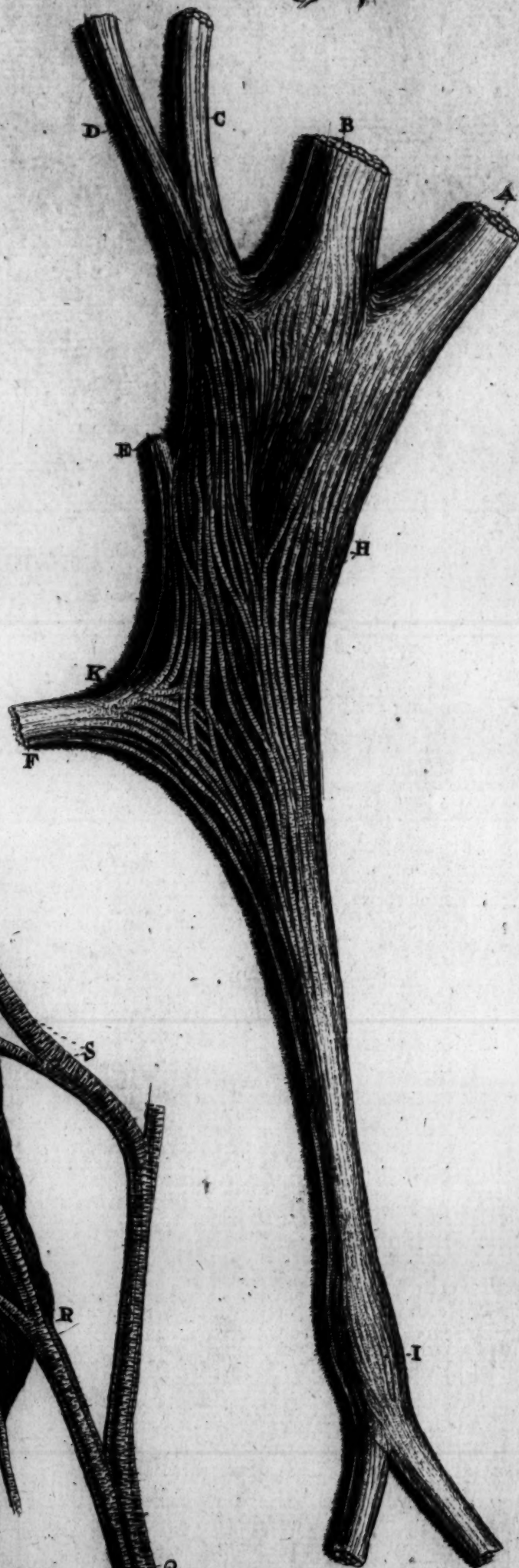
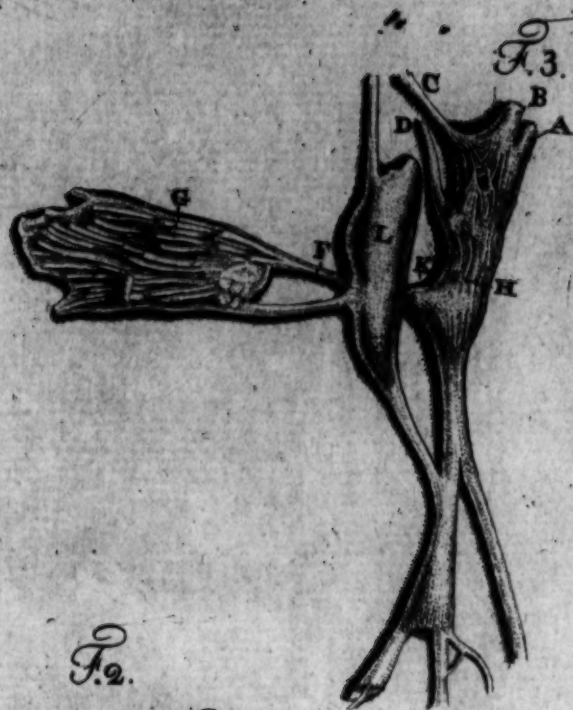
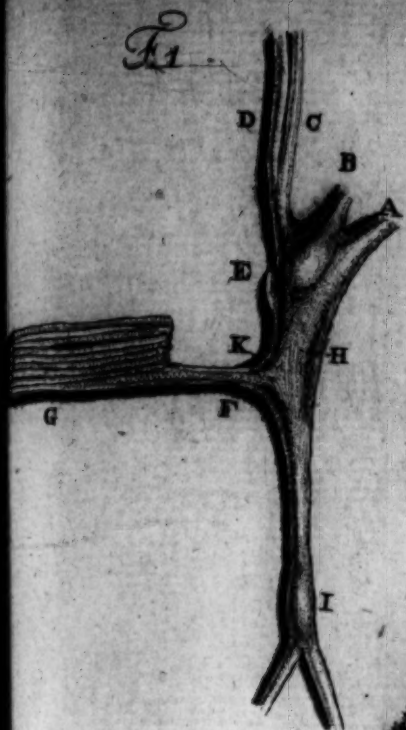


The Donnellon Sculp

Tab. XVII

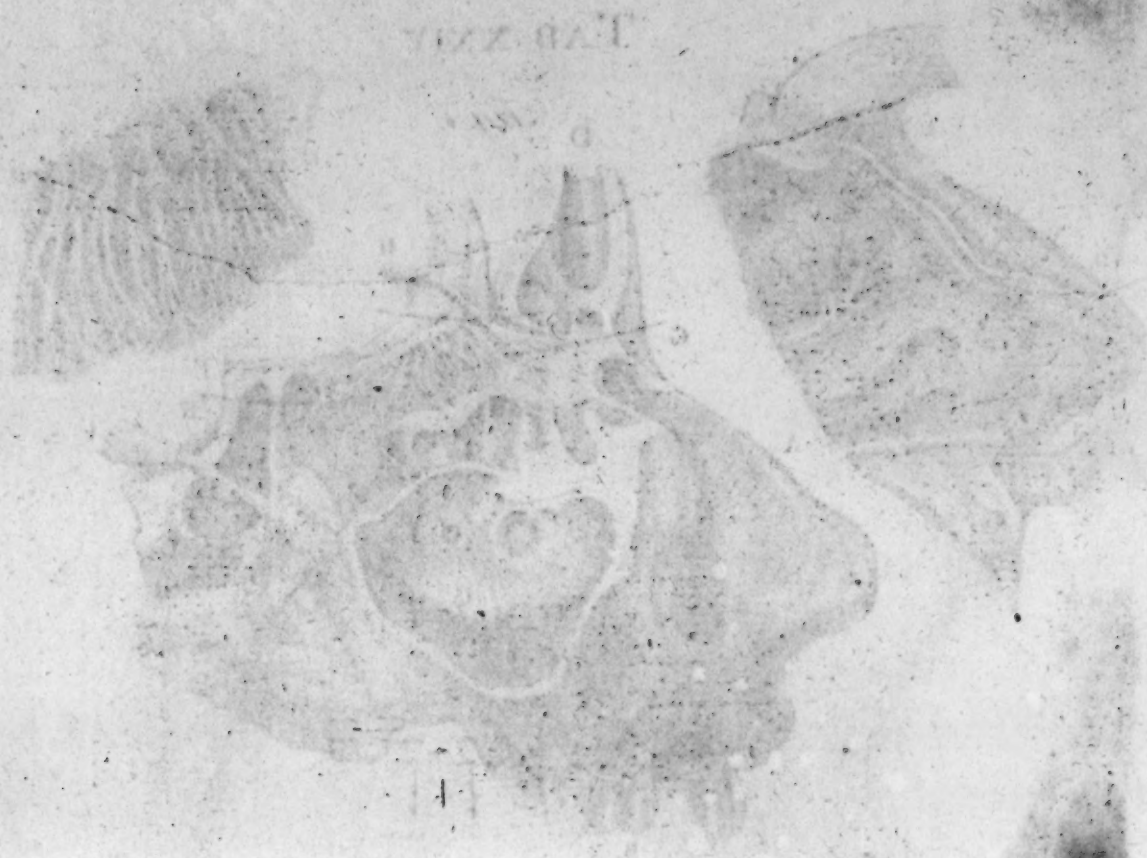


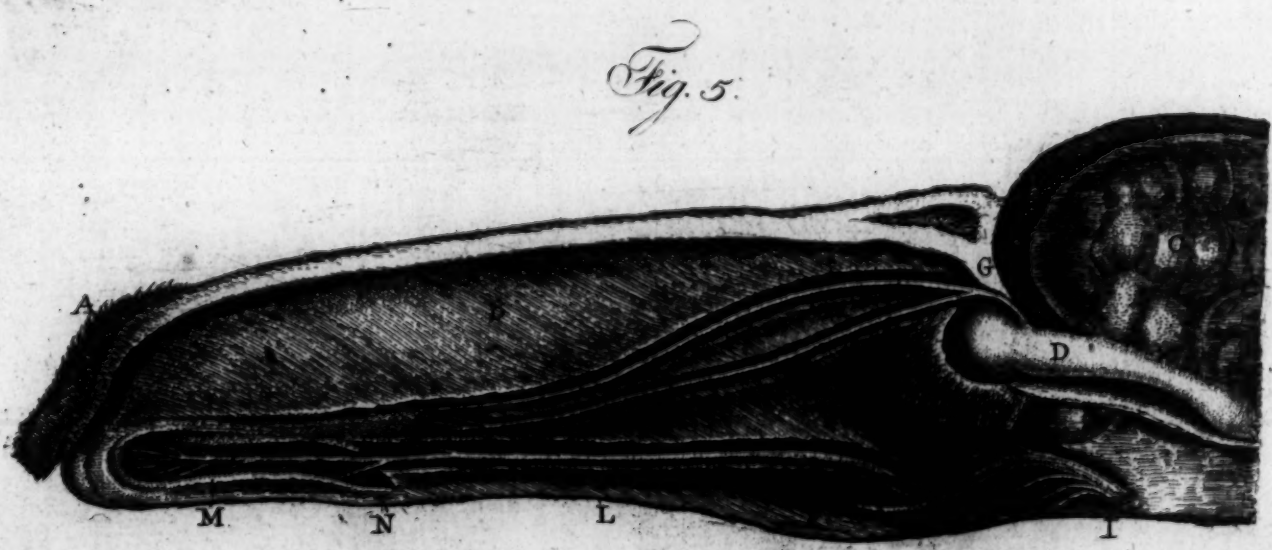
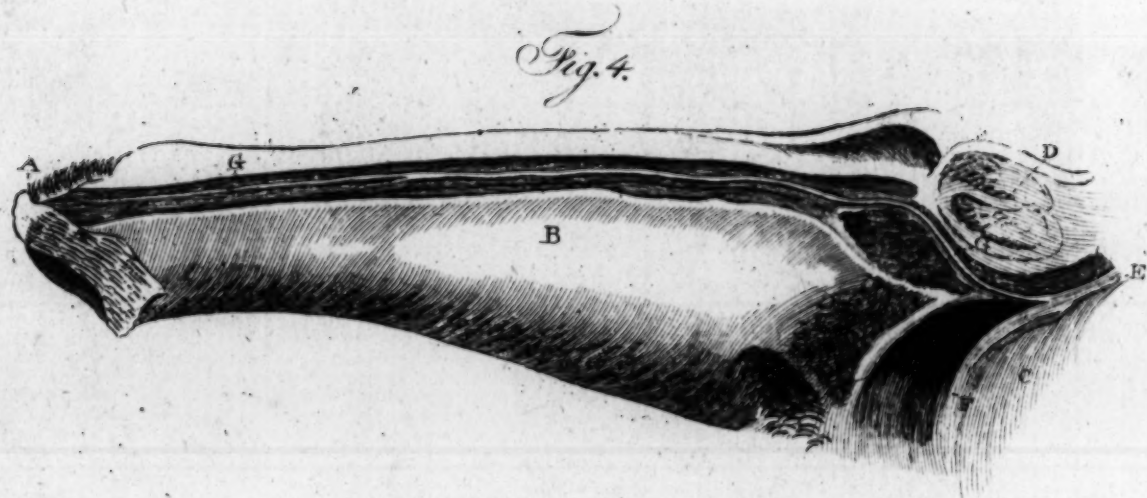
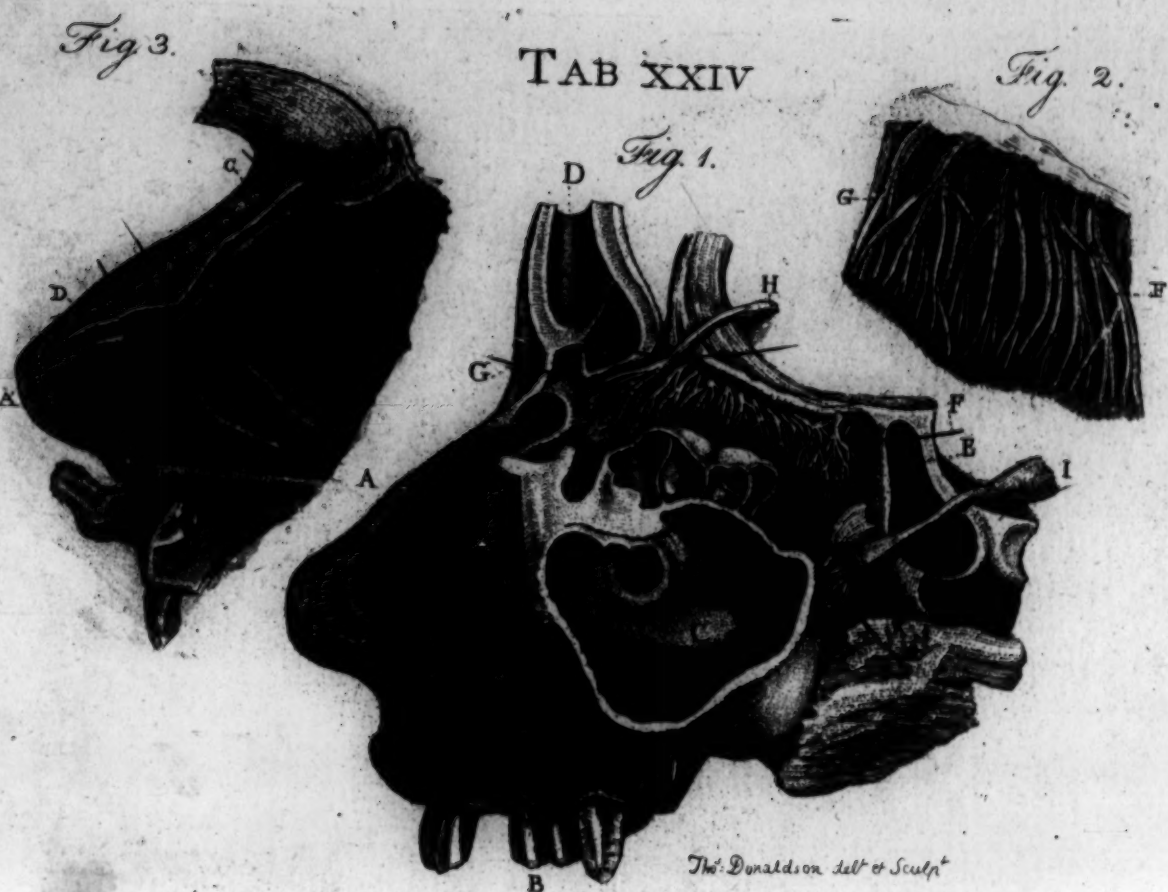
TAB. XXIII



The Donalson Sculp.

TAB. XXII.







TAB. XXV.



TAB. XXVI

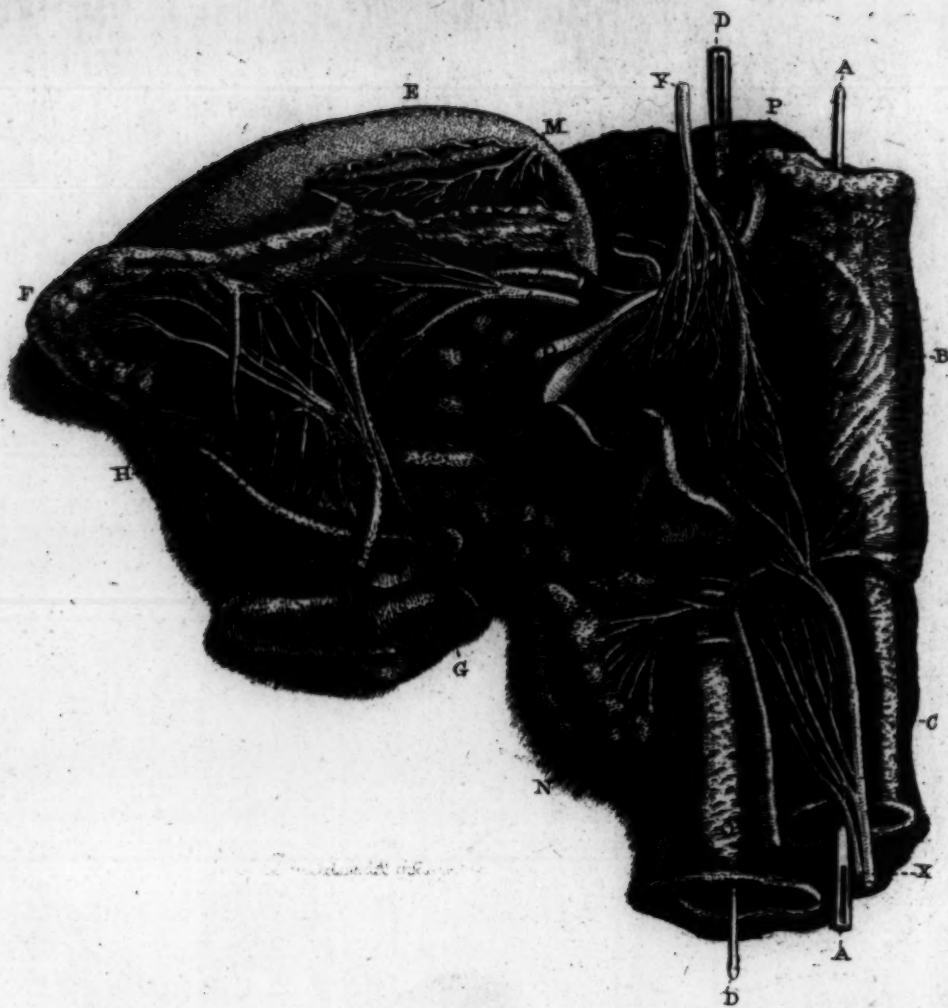


A. Pye del.

G. Cameron sculpt.

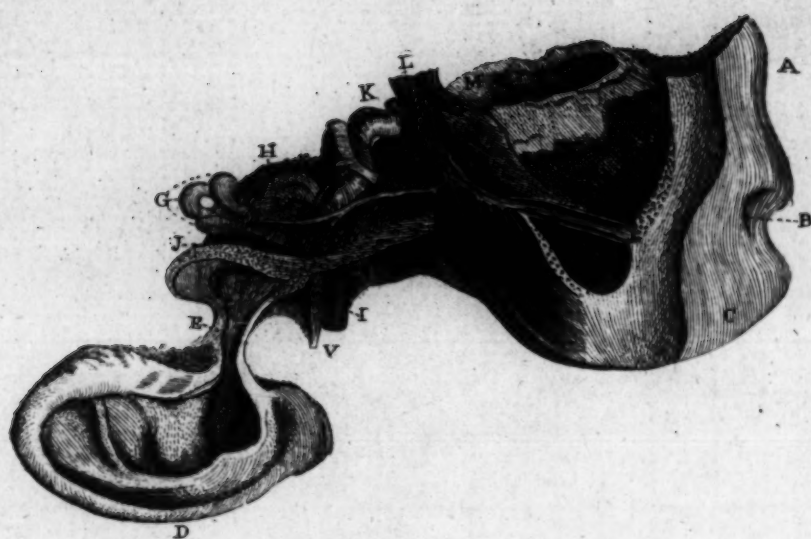


TAB. XXVI. ☒





TAB. XXVII



A. Fryfe del.

G. Cameron sculp.

TAB. XXVIII



Mr. Douglas sculp.

XXXVII



TAB. XXIX

Fig. 1.

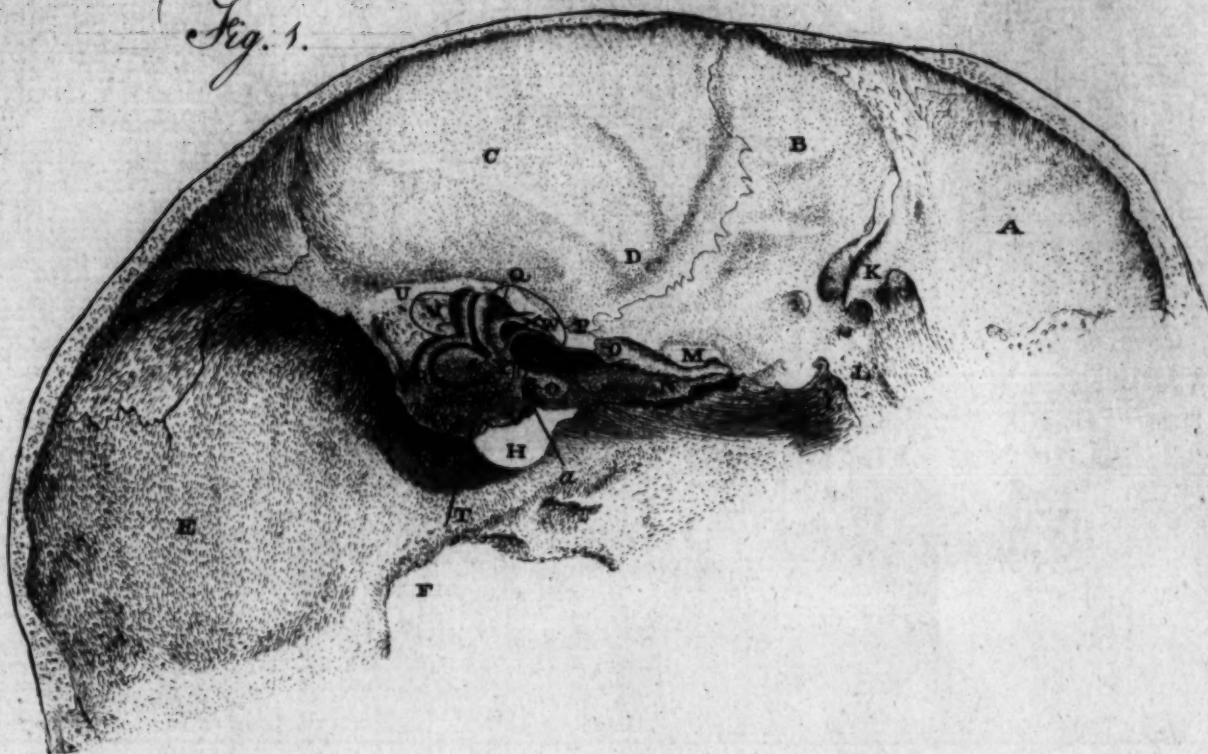
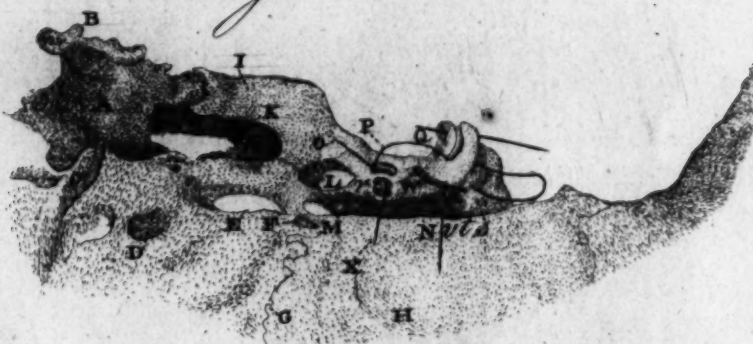


Fig. 2.

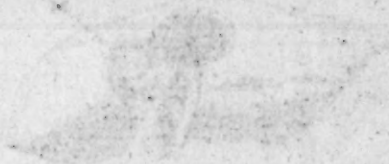
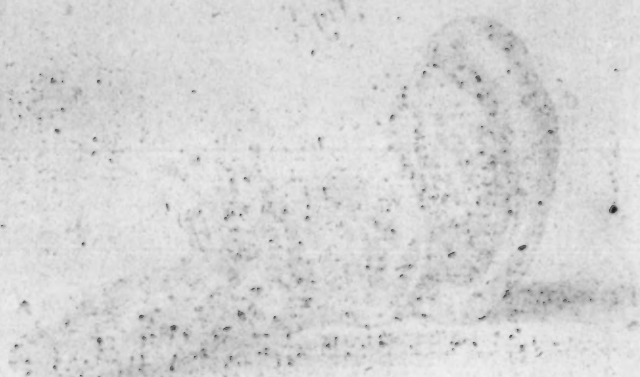


Fig. 3.



A. L. D. 1

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TAB. XXX.

Fig. 1.



Fig. 2.

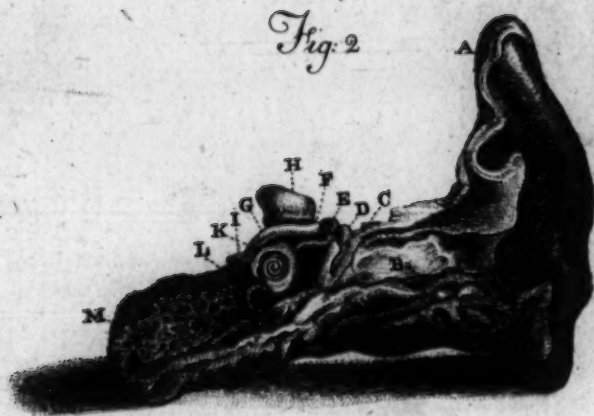


Fig. 3.

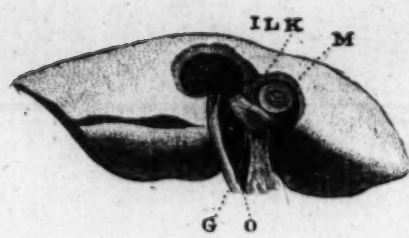


Tab. II.

Fig. 4.



Fig. 5.





TAB. XXXI

Fig. 1.



Fig. 2.

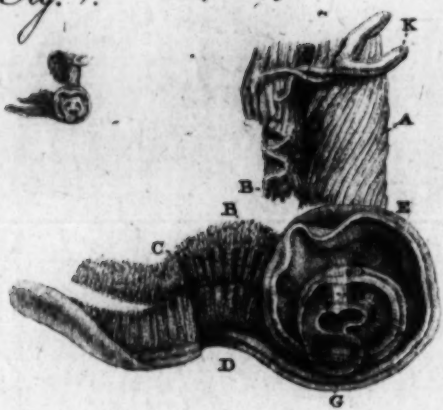


Fig. 3.

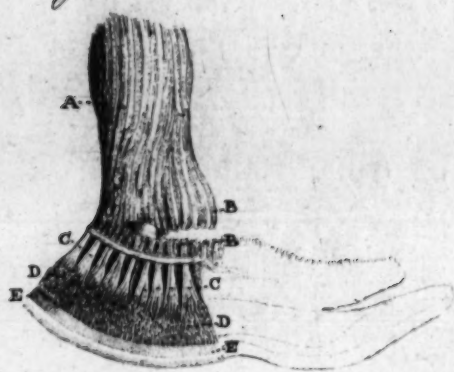
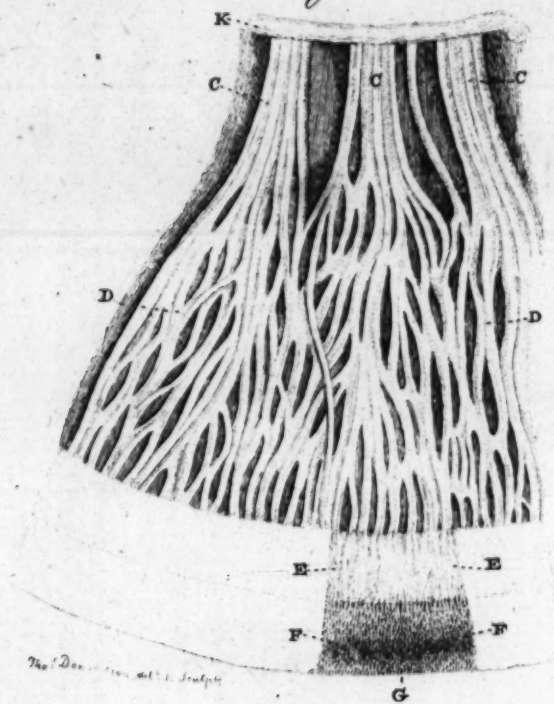


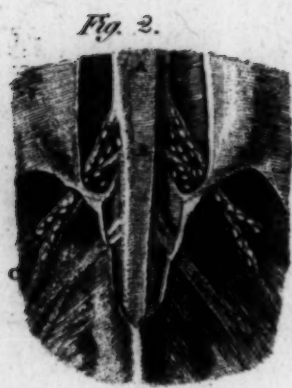
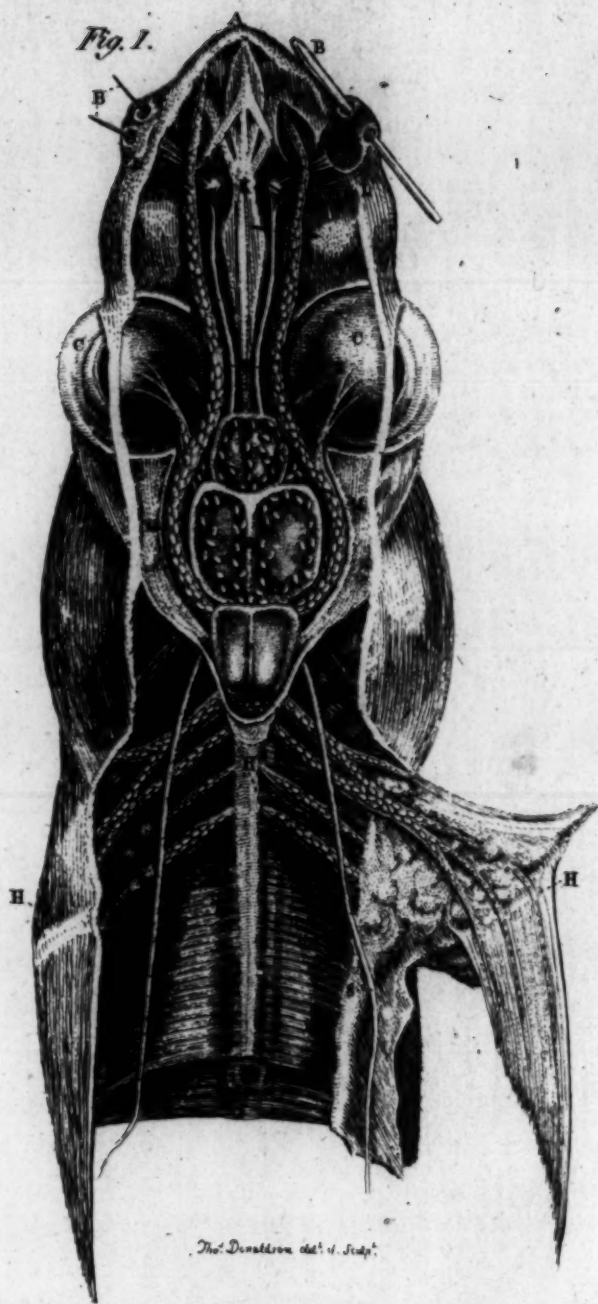
Fig. 4.



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TAB. XXXII





TAB. XXXIII

Fig. 1.



Fig. 2.

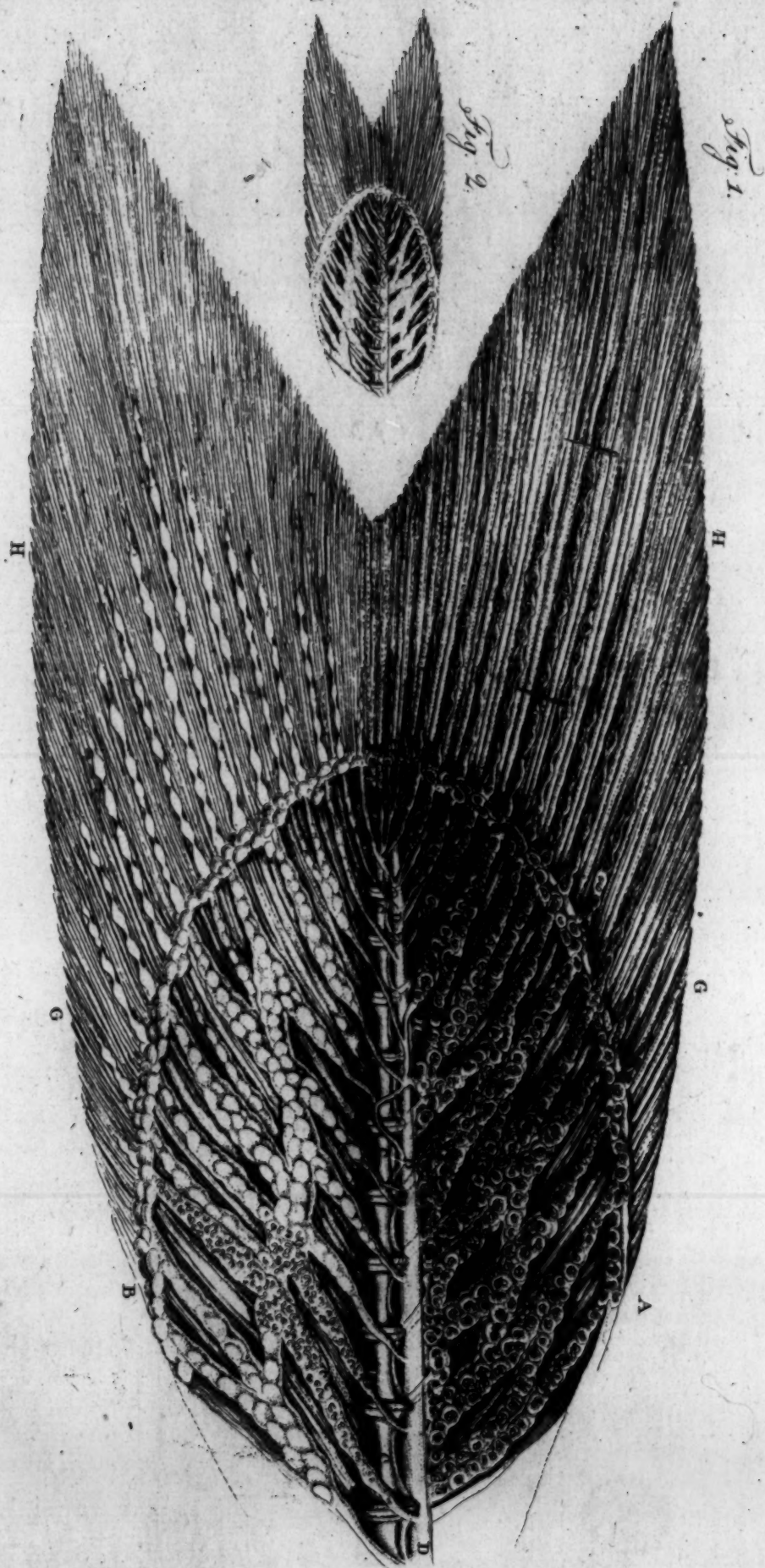


Fig. 3.



Tab. Donaldson del. et J. J. sculp.



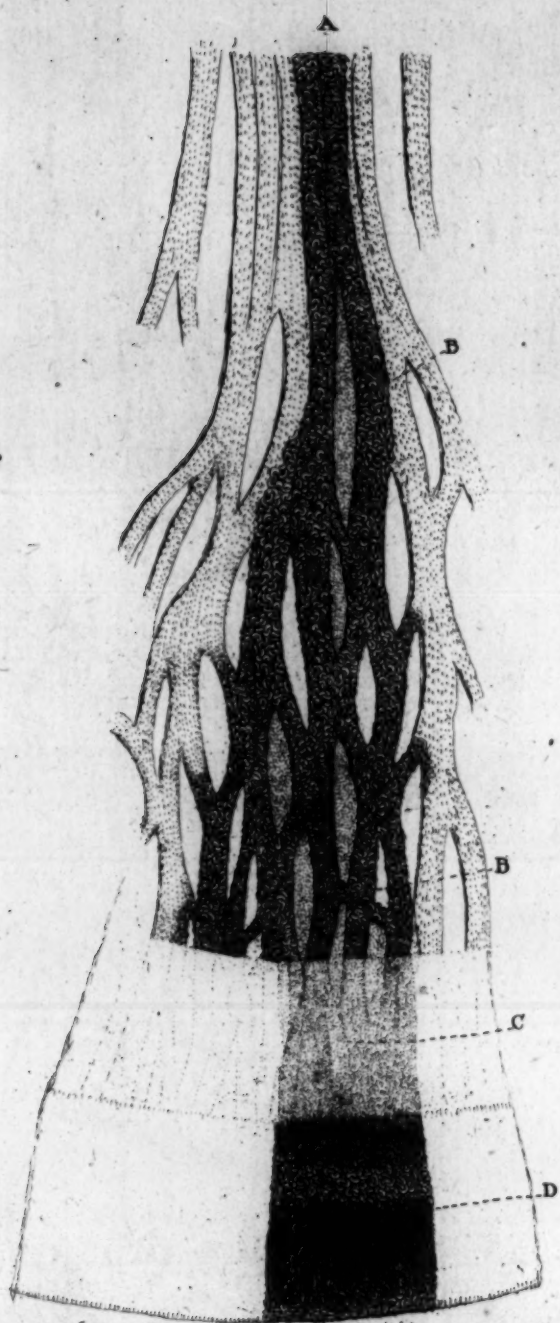


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TAB. XXXV



TAB. XXXVI

Fig. 1



Fig. 2



Fig. 3



Fig. 6



Fig. 4

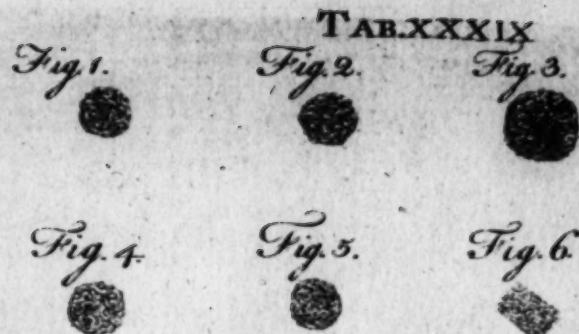
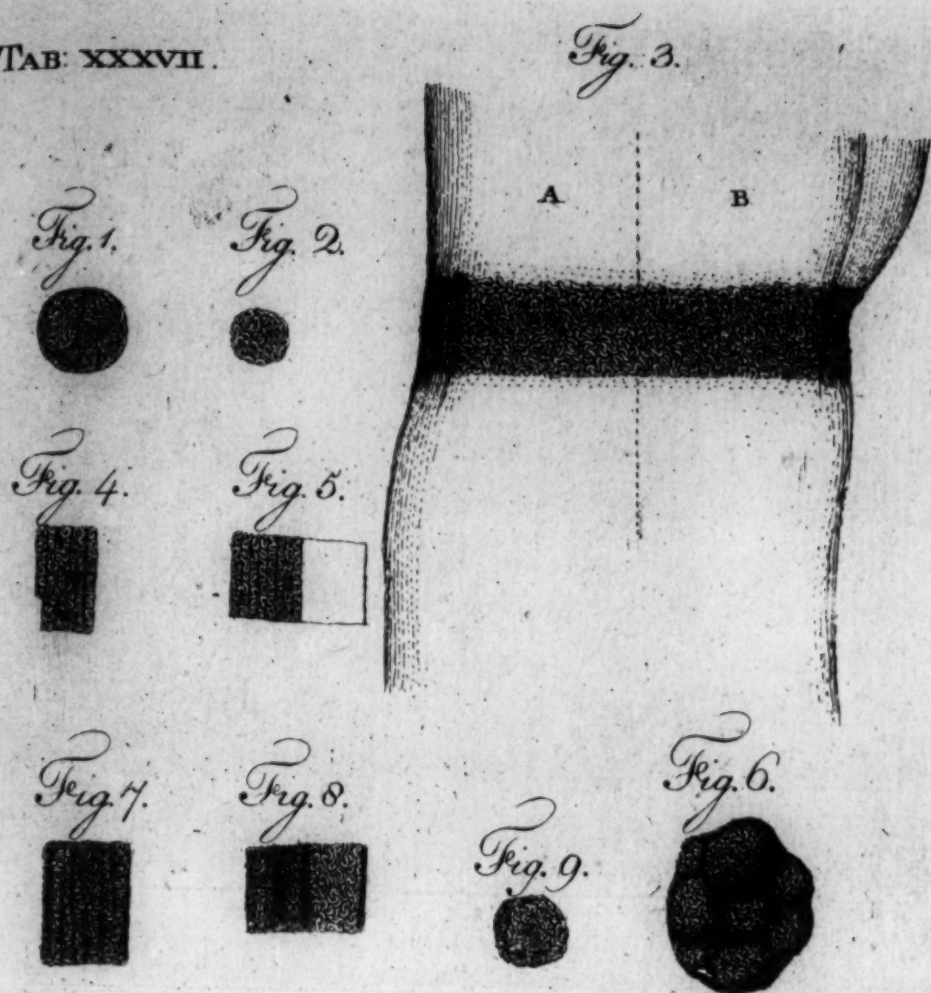


Fig. 5

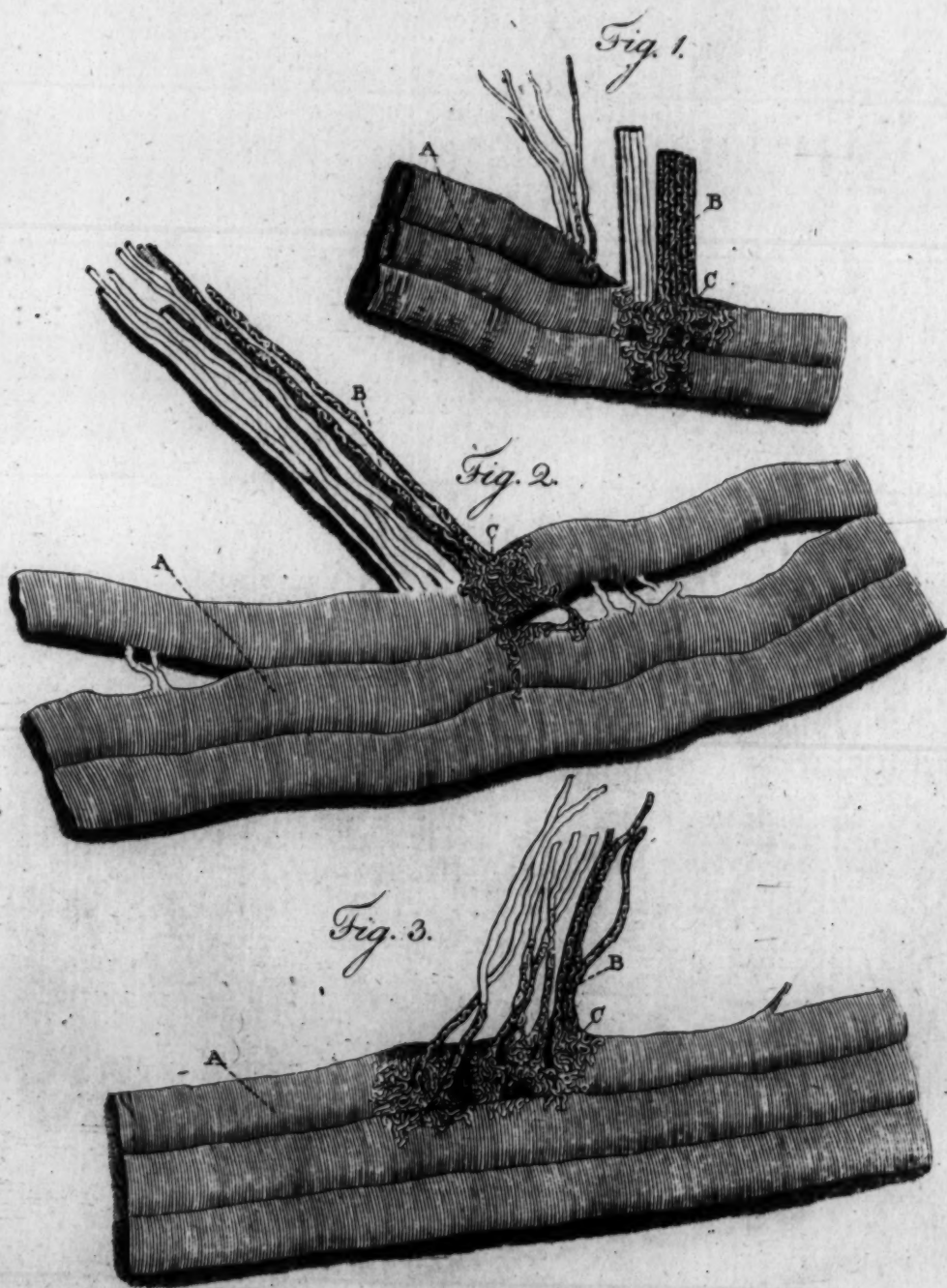




TAB. XXXVII.

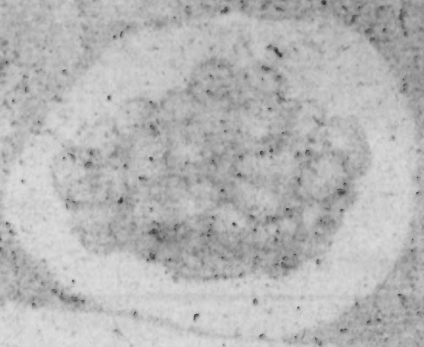


TAB. XXXVIII



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TAB. XL.

Fig. 1st

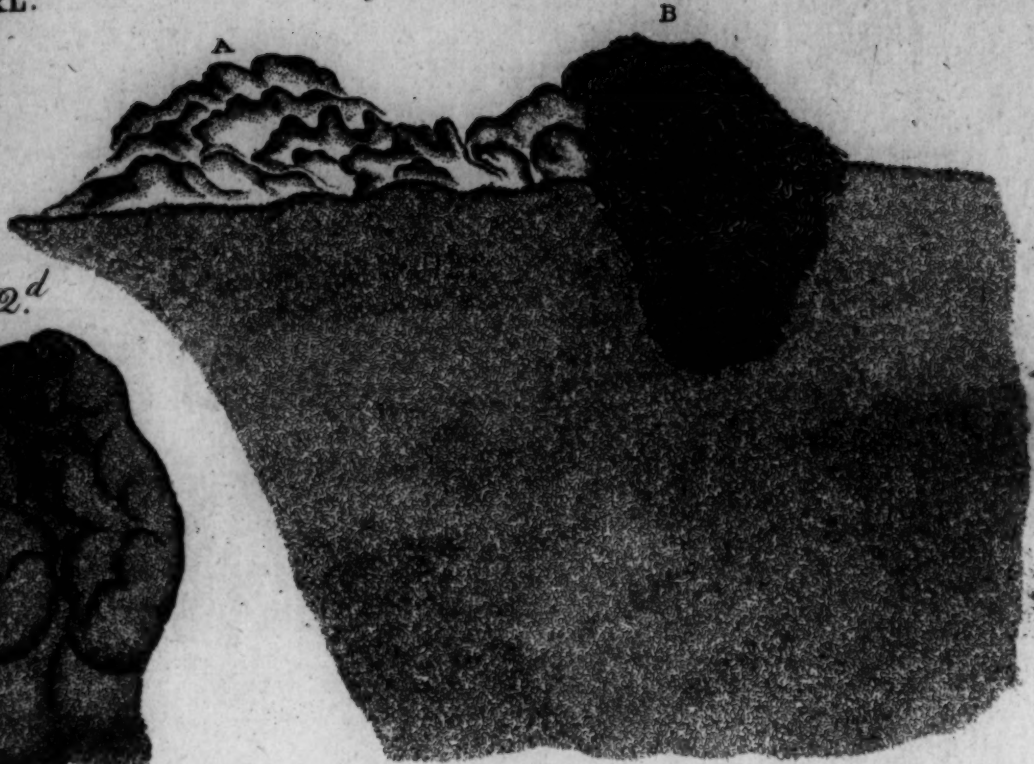
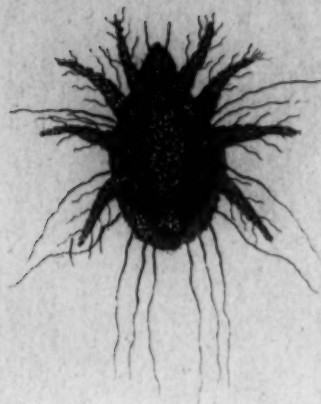


Fig. 2^d



TAB. XLII



TAB. XLI

Fig. 1.

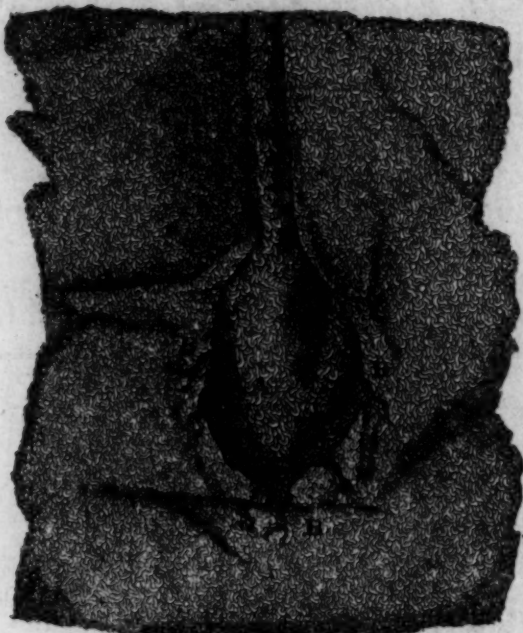


Fig. 2.



Fig. 3.



Fig. 4.



Fig. 5.



Fig. 6.





TAB. XLIII

Fig. 3.

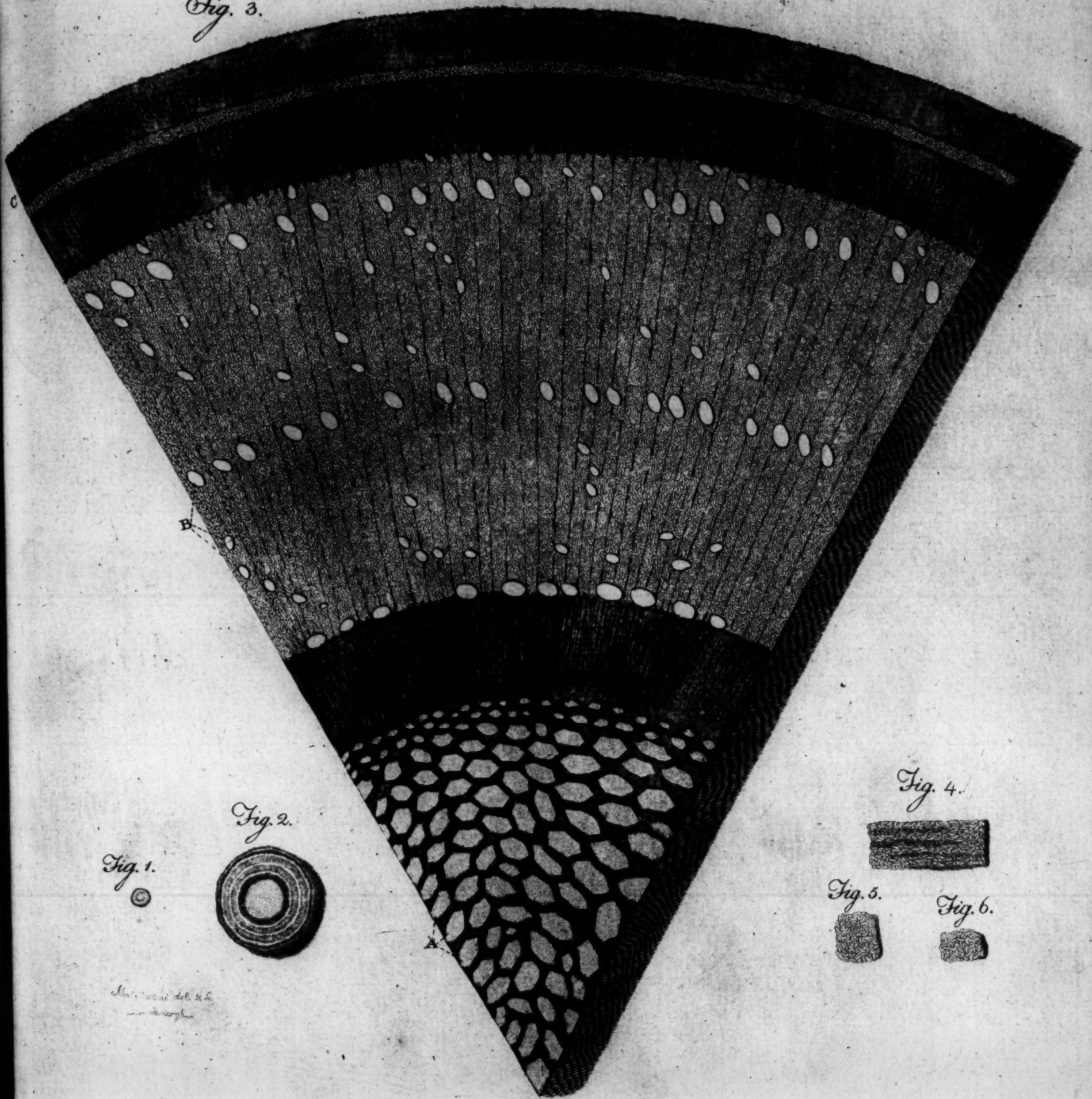


Fig. 1.



Fig. 2.



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in cancrio

Fig. 4.

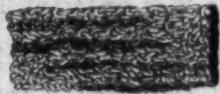


Fig. 5.



Fig. 6.





TAB. XLIV

Fig. 1.



Fig. 2.



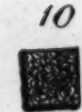
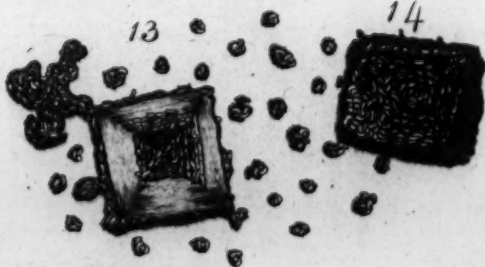
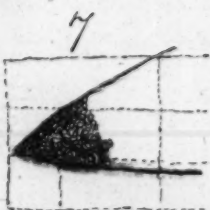
Fig. 3.



Fig. 4.



TAB. XLV



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TAB. XLVI.

Fig. 1.



Fig. 2.

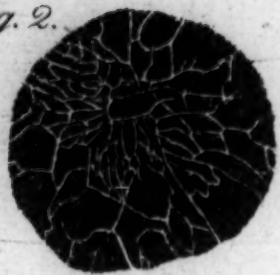


Fig. 3.



TAB. XLVII.

Fig. 1.

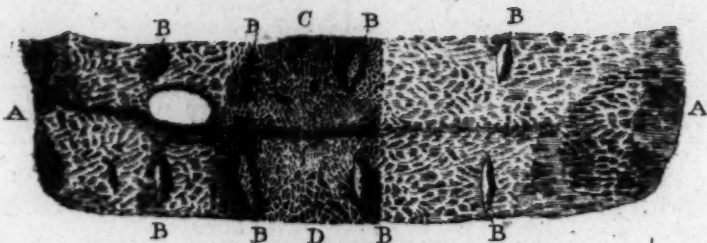


Fig. 2.

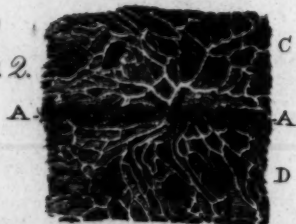


Fig. 3.



Fig. 4.





